(12)

NPS-52AB76031

NAVAL POSTGRADUATE SCHOOL

Monterey, California

EVALUATION OF THE AS-3018/WSC-1(V)
SHIPBOARD SATCOM ANTENNA

Richard W. Adler
John E. Ohlson
Bernard K. Hollar

March 1976

Approved for public release: Distribution unlimited
A task under the Shipboard RFI in UHF SATCOM Project
Prepared for:

Naval Electronic Systems Command
PME 106
Washington, D.C. 20302

NAVAL POSTGRADUATE SCHOOL
Monterey, California

Rear Admiral Isham Linder
Superintendent
15 March 1976

Jack R. Borsting
Provost

ABSTRACT

The AS-3018/WSC-1(V) Satellite Communications Antenna is part of the Antenna Group OE-82B/WSC-1(V). This report describes measurements of gain and radiation patterns both in and out of the nominal operating frequency band. These results demonstrate that it meets manufacturer's specifications and provide information on the antenna's contribution to the shipboard SATCOM system's susceptibility to RFI.

This report was prepared by:

RICHARD W. ADLER
Associate Professor
Dept. of Electrical Engineering

JOHN E. OHLSON
Associate Professor
Dept. of Electrical Engineering

Approved by:

DONALD E. KIRK
Chairman
Dept. of Electrical Engineering

Released by:

ROBERT R. FOSSUM
Dean of Research Administration

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER (14) NPS-52AB76031	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER UNCLASS.
4. TITLE (and Subtitle) (6) EVALUATION OF THE AS-3018/WSC-1(V) SHIPBOARD SATCOM ANTENNA,		5. TYPE OF REPORT & PERIOD COVERED (9) Task Report,
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) (10) Richard W. Adler, John E. Ohlson, Bernard K. Hollar		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, CA 93940		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS N000 3976 WR 69117
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Electronics Systems Command PME-106 Washington, D.C. 20362		12. REPORT DATE (11) March 1976 (12) 62p.
		13. NUMBER OF PAGES 61
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release: Distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Antennas
SATCOM
RFI
Shipboard

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The AS-3018/WSC-1(V) Satellite Communications Antenna is part of the antenna group OE-82B/WSC-1(V). This report describes measurements of gain and radiation patterns both in and out of the nominal operating frequency band. These results demonstrate that it meets manufacturer's specifications and provide information on the antenna's contribution to the shipboard SATCOM system's susceptibility to RFI.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

251 450

TABLE OF CONTENTS

I. INTRODUCTION

A. OBJECTIVE

This investigation was for the purpose of determining the gain and directivity of the AS-3018/WSC-1(V) shipboard SATCOM antenna both in and out of the nominal operating frequency band. The antenna was designed for the 240-312 MHz range. Tests were run from 200-900 MHz.

The results of the measurements provide:

1. A check on some of the manufacturer's specifications
2. An indication of the antenna's role in the shipboard UHF SATCOM system's susceptibility to RFI.

In addition to tests on the AS-3018, a commercial conical log spiral EMI antenna (EMCO Model 3103) was evaluated. This work was undertaken as a preliminary task under the Shipboard RFI in UHF SATCOM project to provide needed antenna calibration information.

B. DESCRIPTION OF MEASUREMENT FACILITIES

The AS-3018 was mounted on a Scientific-Atlanta elevation-over-azimuth positioner, as shown in Figure 1, which is part of the rooftop antenna range on Spanagel Hall at the Naval Postgraduate School. As is typical, this test antenna was used as a receiving antenna with the transmitting radiator being selected from (1) a broadband dipole (AT-150/SRC), (2) tuned standard dipoles or (3) a circularly polarized conical log-spiral, the choice being dependent on the tests conducted.

The range is equipped with a collection of signal generators, which serve as transmitters, a field intensity meter for receiving and a polar pattern plotter for recording radiation patterns.

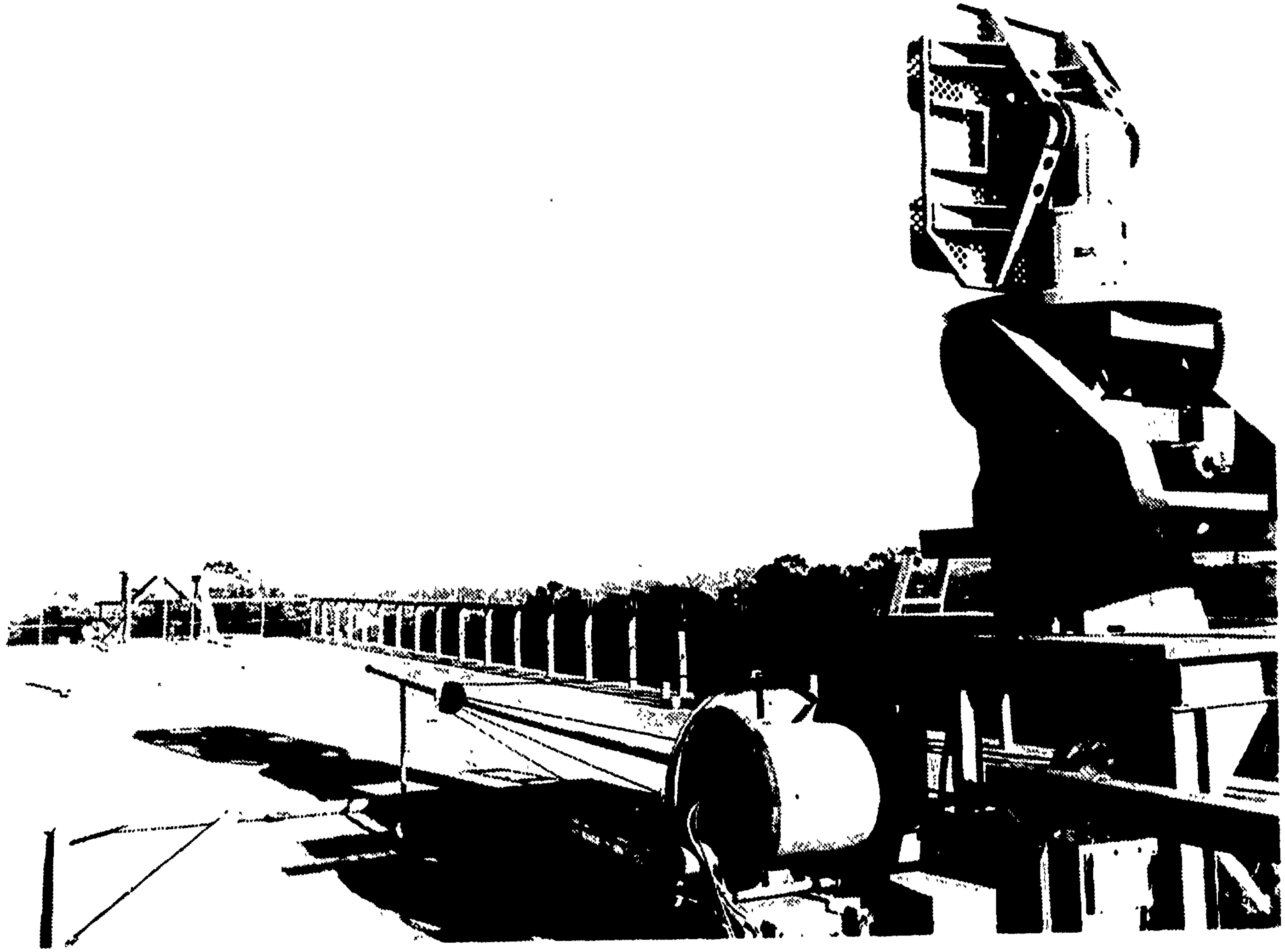


FIGURE 1. AS-3018 ANTENNA SHOWN IN POSITION ON THE NPS ROOF-TOP RANGE. THE AT-15C SRC TRANSMIT DIPOLE IS AT THE FAR END OF THE RANGE.

C. ANTENNA RANGE LIMITATIONS

The ideal range for gain and pattern measurements is labelled a "Free Space Range" because it closely approximates free space conditions, i.e., the antenna under test will be receiving a single, perfect plane wave (uniform amplitude, plane phase front). On real-world antenna ranges, practical limitations produce two major conditions which limit the accuracy of gain and pattern measurements [1]:

1. Phase front curvature of the incoming wave of greater than $\lambda/16$ (22°) can result in pattern measurement errors of null depth and minor lobe levels.

2. Reflections from surroundings can produce standing waves which result in non-uniform amplitude and phase of the transmitted wave as measured at the test antenna. This condition can cause large gain and pattern errors, depending on the severity of the reflections, which will vary greatly with frequency.

The first limitation can be prevented by making the range distance, R, such that

$$R > 2d^2/\lambda \quad \text{(or } 3\lambda\text{, whichever is greater)}$$

See Figure 2 for identification of terms. The low frequency limit of 200 MHz corresponds to λ of 1.5 M; with R of 29 M and d of 1 M; the 2 d^2/λ criterion is met for the worst case.

The second limitation is difficult to completely overcome. Some of the conditions which, in part, eliminate reflection effects are:

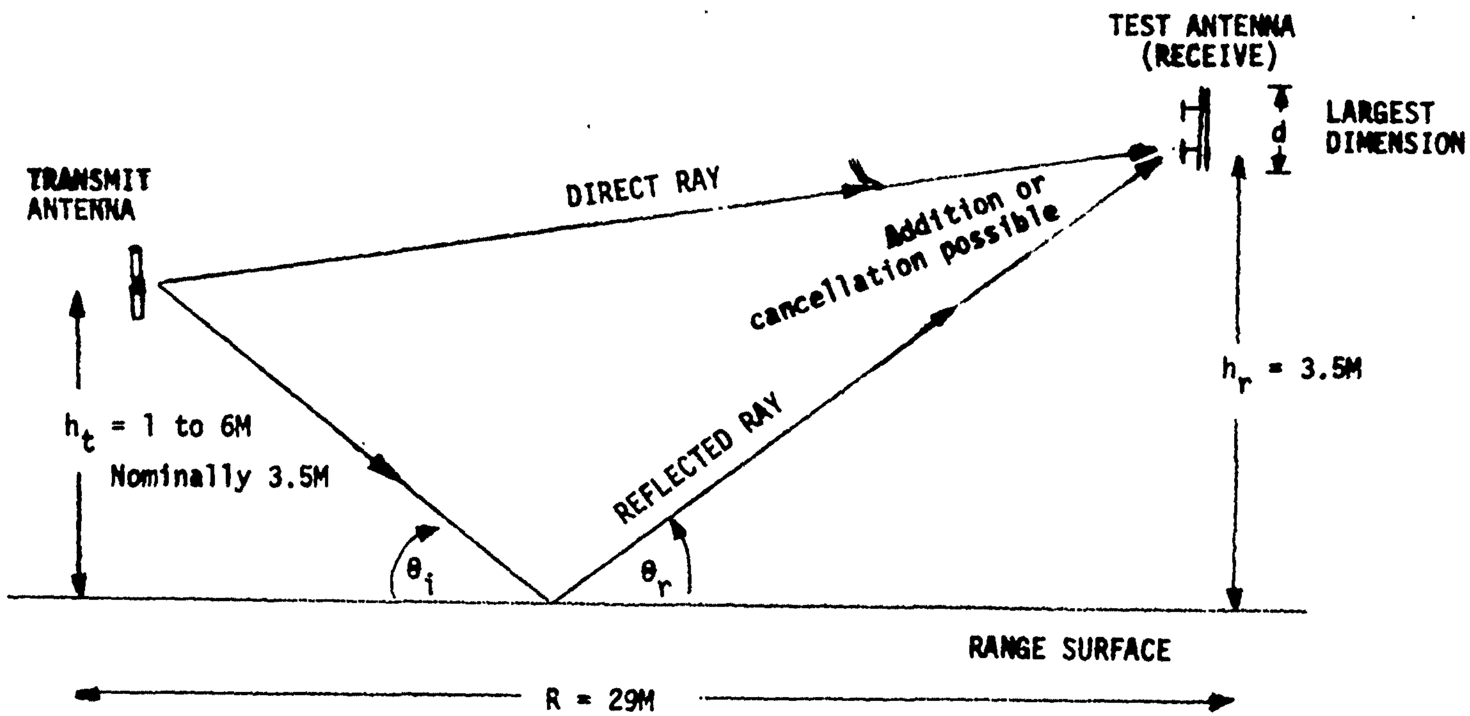


FIGURE 2. RANGE CONFIGURATION SHOWING RAYS

a. The angles of incidence, θ_i, and reflection, θ_r, should be as small as practicable to assure a "grazing" condition for the reflected wave. This will make the range performance insensitive to variations in transmit and receive antenna heights. For fixed heights, variations, being wavelength dependent, will occur with frequency. Either wide variations of height (in our case, height is fixed) or frequency will negate the grazing condition. The 200 t 900 MHz range thus eliminates this condition as a useful one.

b. Transmitting antenna directivity can be used to reduce illumination of reflecting surfaces of the range or

c. Elevate the test and source antennas when both must be broad-beam radiators to achieve the same condition.

Neither choice b nor c can be applied in this situation. Increasing antenna directivity to a point where reflections are reduced to a tolerable level would require a transmitting aperture of from 10 M at 200 MHz to 3 M at 900 MHz, clearly unmanageable. The height to which the source and test antennas must be raised in order to reduce reflections to a level where gain errors are less than ±1 dB is approximated

$$h \geq 2.84R \quad \text{or} \quad 82\ \text{M}, \quad \text{likewise impractical}$$

The conclusion is that the reflected wave on the antenna test range cannot be eliminated by combinations of directive transmit antennas and increased range dimensions and that some addition and cancellation of the direct wave will occur as a function of frequency with attendant gain and pattern variations. This is not unlike a real shipboard environment with the result that the measurements made give some indication of the performance to be expected at a somewhat "cluttered" site.

D. EVALUATION OF RANGE REFLECTIONS

To evaluate the severity of reflections, which will be most apparent at low frequencies, a test was conducted. The AT-150/SRC broadband "fat" dipole (200-400 MHz) was used as the source radiator at 300 MHz. The SATCOM antenna was used as the receive antenna and the received signal strength, a combination of both direct and reflected waves, was plotted as the dipole was elevated from 1 to 6 M, and is shown in Figure 3 as the solid curve. Note that a somewhat cyclic variation of 9-10 dB peak-to-peak occurs. From Reference 1 it can be determined that such a variation is caused by a reflected wave which is only 2 to 9 dB below the direct wave and that this can produce a gain and pattern error as high as ±5 dB. As was stated earlier, if the range were operated with fixed antenna heights but variable frequency, similar ref[illegible]on-caused field variations would be experienced.

E. REDUCTION OF RANGE REFLECTIONS

If the undesirable reflections could be reduced to an acceptable level by some type of "shield" or screen, the pattern and gains measured would be more useful. Diffraction fences on the range surface can redirect a part of the reflected energy away from the test antenna. Since such fences must necessarily also intercept a small portion of the incident wavefront, they simultaneously produce small variations in the transmitted signal in the form of diffraction effects from their edges. Thus, such a fence will be a compromise between the desired suppression of reflections and the lesser undesired residual diffraction. Several such fences, up to a total of three,

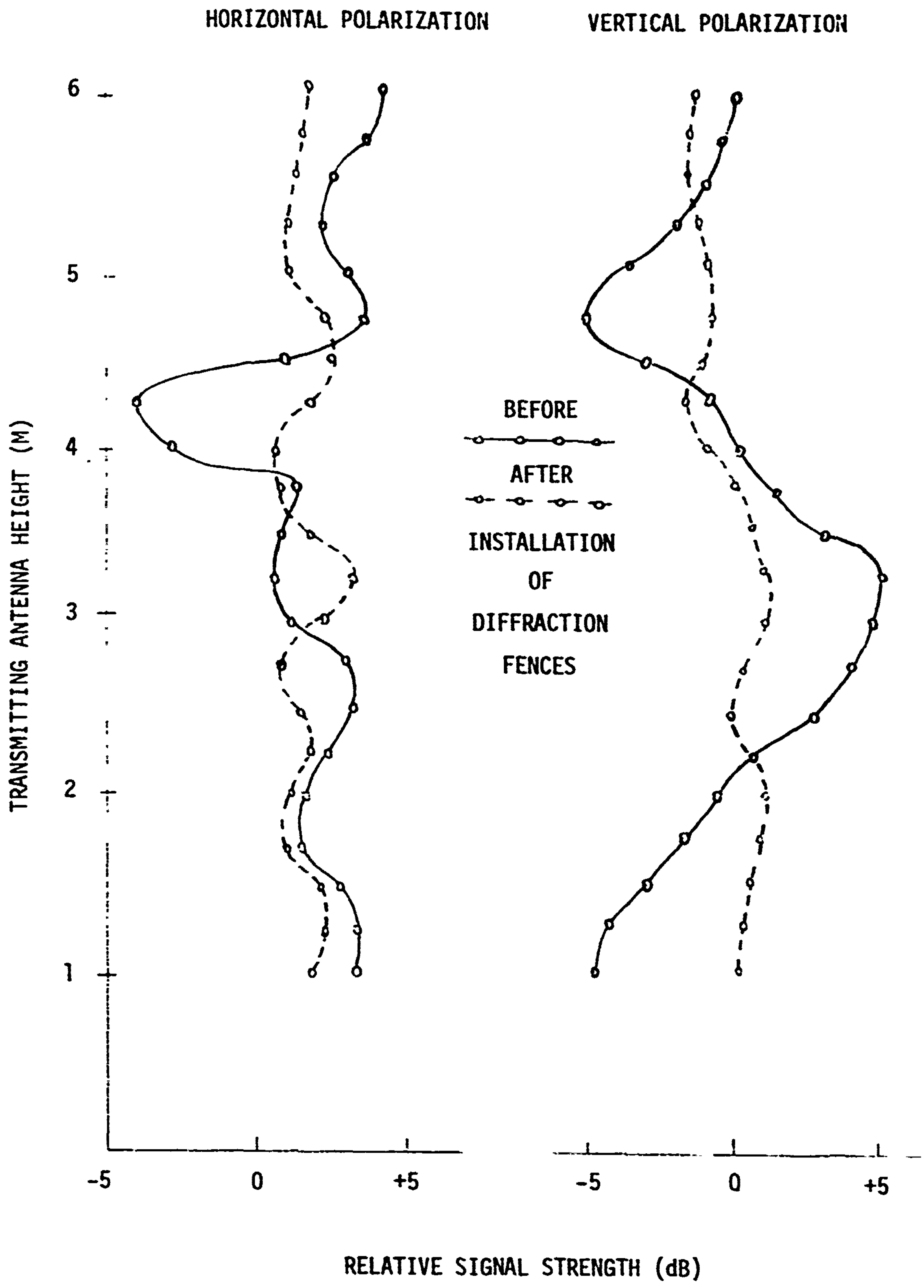


FIGURE 3. FIELD STRENGTH VARIATIONS AT TEST ANTENNA AS SOURCE ANTENNA IS ELEVATED

can be effective over a range of frequencies typically encountered. Each fence must be experimentally tilted and skewed to suppress multiple bounce effects. Figure 4 shows the placement found optimum for the roof range at the Naval Postgraduate School.

After installation of the aluminum screen fences, a repeat run of the field strength received by the SATCOM antenna vs. transmit antenna height was plotted in Figure 3 as the dotted curve. The reduction of variation to about 2-3 dB peak-to-peak reveals a reflected wave level of -15 dB with respect to the incident wave at 300 MHz. This could produce gain and pattern variations of up to 1.5 dB, a tolerable value. Spot checks at 280 MHz revealed the same results. At higher frequencies reflection degradation is not expected to be as severe, this being verified by a 400 MHz measurement yielding less peak-to-peak field variation.

II. MEASUREMENTS AND RESULTS

A. PEAK GAIN VS. FREQUENCY

The value of the peak gain is found at the maximum point of the major lobe at 0° elevation angle. Gain is referred to an idealized, isotropic radiator. Since the isotrope is fictional, an existing antenna whose gain over the isotrope is known, must be used as a "standard" antenna against which to compare the test antenna.

A conical log spiral (EMCO Model 3103) was purchased and believed to be such an antenna. Upon close inspection of the manufacturer's calibration data, it was discovered that the "gain" figures were obtained at a distance of one meter (a commonly accepted distance for EMI measurements). This suggested that the data was for a "near field" condition below 900 MHz,

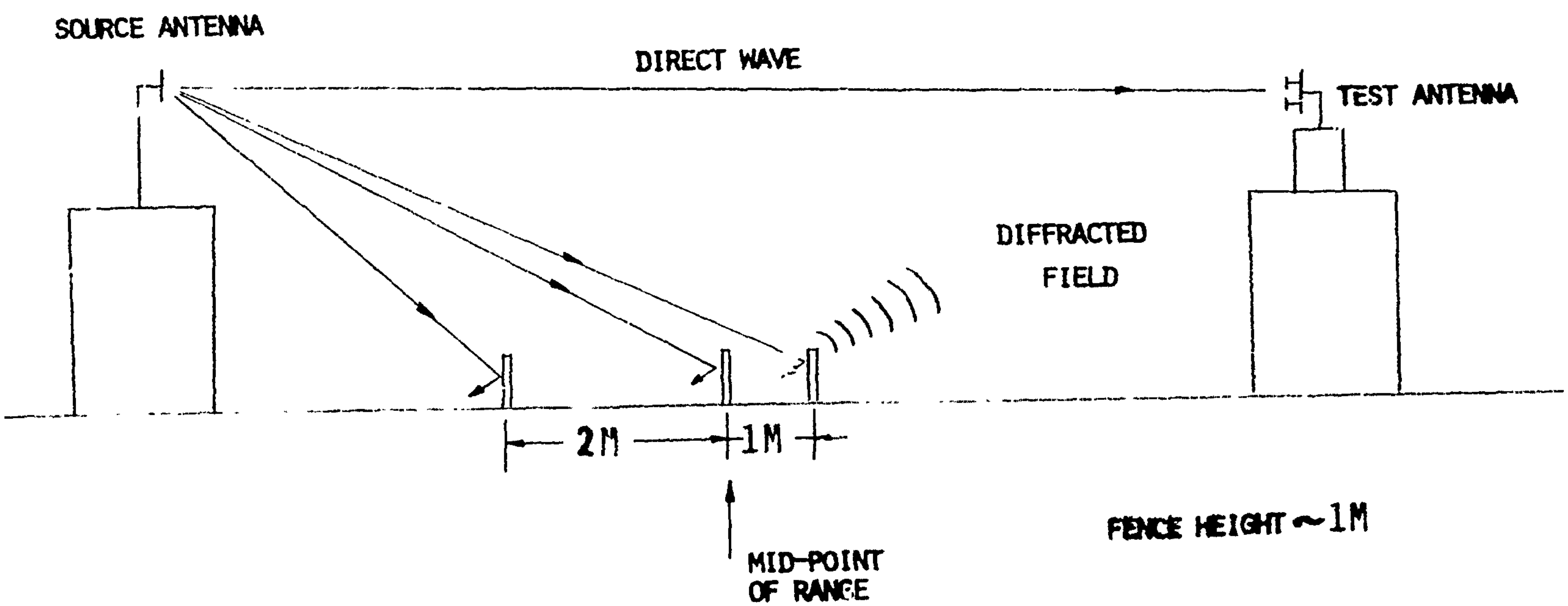


FIGURE 4. PLACEMENT OF CONDUCTING FENCES USED TO REDUCE REFLECTED WAVES

rendering it of questionable worth for this experiment where "far field" conditions are assumed. Since this spiral antenna was also to be used in shipboard RFI tests, it would be measured along with the AS-3018 using a "standard" tuneable dipole as a reference antenna.

Two dipoles, the Stoddard Model 91870-2 for 88 to 400 MHz and the 91598-2 for 370 to 1000 MHz, part of the NM 30A Field Intensity Meter test set, were used as gain standards having ~2 dB gain with respect to an isotropic radiator. The procedure for gain measurements was as fol´ .ıs:

The AT-150/SRC dipole was used for transmitting in the 200-400 MHz range. Since both antennas under test were nominally circularly polarized, and a linearly polarized transmit antenna was used, the method of establishing maximum and minimum response of the test antenna to an arbitrarily-oriented linearly polarized wave had to be used for a measure of circular polarization response. Thus, the transmitting antenna had to be rotated (in a vertical plane) until a maximum received reading was noted from the antenna under test. The transmit antenna was secured at this position. Next a tuneable dipole was mounted on a non-conducting tripod and raised to the same relative position as the test antenna, and rotated for a maximum reading which was recorded. The reading from the tuneable standard dipole was corrected to an isotropic value and the difference between this reading and that of the test antenna was determined as the "linearly polarized peak gain" of the test antenna with respect to an isotropic radiator. For the range of 400-900 MHz, two 91598-2 tuneable dipoles were used for both transmit and the receive standard and the above procedures duplicated.

To determine circularly polarized gain, the procedure was repeated except that minimum readings were noted on the test antennas. The tuneable dipoles were also used in the same way to get a reading at minimum position of the transmitting dipole. The difference between the maximum and minimum readings on the test antennas at a specific frequency yields a representation of the axial ratio (to be discussed later).

The difference between maxima on a test antenna and the standard (adjusted to isotropic) gives a linear polarization gain at that position of the transmit antenna. Similarly, the minimum reading differences give another linear polarization gain (its orientation was approximately 90° from the maximum position). Circular polarization (CP) gain is found from

$$\text{Gain}_{CP} = (\text{MAX Gain}^2 + \text{MIN Gain}^2)^{1/2}$$

where the gain values are voltage ratios read from the pattern range receiver's meter.

Table 1 gives the results for the SATCOM antenna and Table 2 shows gain for the conical log spiral. Graphs for comparison to the manufacturer's data are given in Figures 5 and 6. The agreement with the SATCOM antenna manufacturer's data was good. For the conical log-spiral, the offset in the curve is attributed to the published data not being for a far-field condition.

B. AZIMUTH PATTERNS VS. FREQUENCY

Polar field patterns were obtained in the azimuth plane at elevation angles of 0°, 10°, 50° and 90°. The circularly polarized illumination of the test antennas was provided by the conical log spiral antenna.

	MEASURED FIELD INTENSITIES				PEAK GAIN		TOTAL GAIN (CP)
	STANDARD DIPOLE		SATCOM ANTENNA		SATCOM ANTENNA		SATCOM ANTENNA
FREQUENCY (MHz)	MAX (dB)	MIN (dB)	MAX (dB)	MIN (dB)	MAX (dB)	MIN (dB)	(dB)
205	23.5	22.5	23.5	19	0	-3.5	1.6
225	24.5	24	31	26	6.5	2	8
240	25.5	24	35	31	9.5	7	11.4
260	32.5	32	42.5	39	10	7	11.8
280	32.0	30	39	36	7	6	9.6
300	32.0	31	41	37	9	6	10.7
320	32.5	32	39.5	34	7	2	8.2
360	31	30	36.5	30	5.5	0	6.6
400	28	26.5	25	19	-3	-7.5	-1.8
500	24	23	2	-3	-22	-26	-20.4
600	12	12.5	19	15	7	3	8.5
700	22	21	9	5	-13	-16	-11.2
800	18	18	13	8	-5	-10	-3.8
900	14	12.5	19	12	5	-.5	6.1

TABLE 1. MEASURED PEAK CP GAIN VS. FREQUENCY FOR SATCOM ANTENNA

	MEASURED FIELD INTENSITIES				PEAK GAIN		TOTAL GAIN (CP)
	STANDARD DIPOLE		CONICAL ANTENNA		CONICAL ANTENNA		CONICAL ANTENNA
FREQUENCY (MHz)	MAX (dB)	MIN (dB)	MAX (dB)	MIN (dB)	MAX (dB)	MIN (dB)	(dB)
205	23.5	22.5	16	10	-7.5	-12.5	-6.3
225	24.5	24	18	13	-6.5	-9	-4.6
240	25.5	24	21	17	-4.5	-7	-2.5
260	32.5	32	29	28	-3.5	-4	-.7
280	32	30	30.5	27	-1.5	-3	.8
300	32	31	32	28	0	-3	1.7
320	32.5	32	32	29	-.5	-3	1.4
360	31	30	33	30	2	0	4.1
400	28	26.5	32	30	4	3.5	6.8
500	24	23	28	23	4	0	5.5
600	12	12.5	16	13	4	1.5	6
700	22	21	20	21.5	4	.5	5.8
800	18	18	23	21.5	5	3.5	7.3
900	14	12.5	18	15	4	2.5	6.3

TABLE 2. MEASURED PEAK CP GAIN VS. FREQUENCY FOR CONICAL LOG SPIRAL ANTENNA

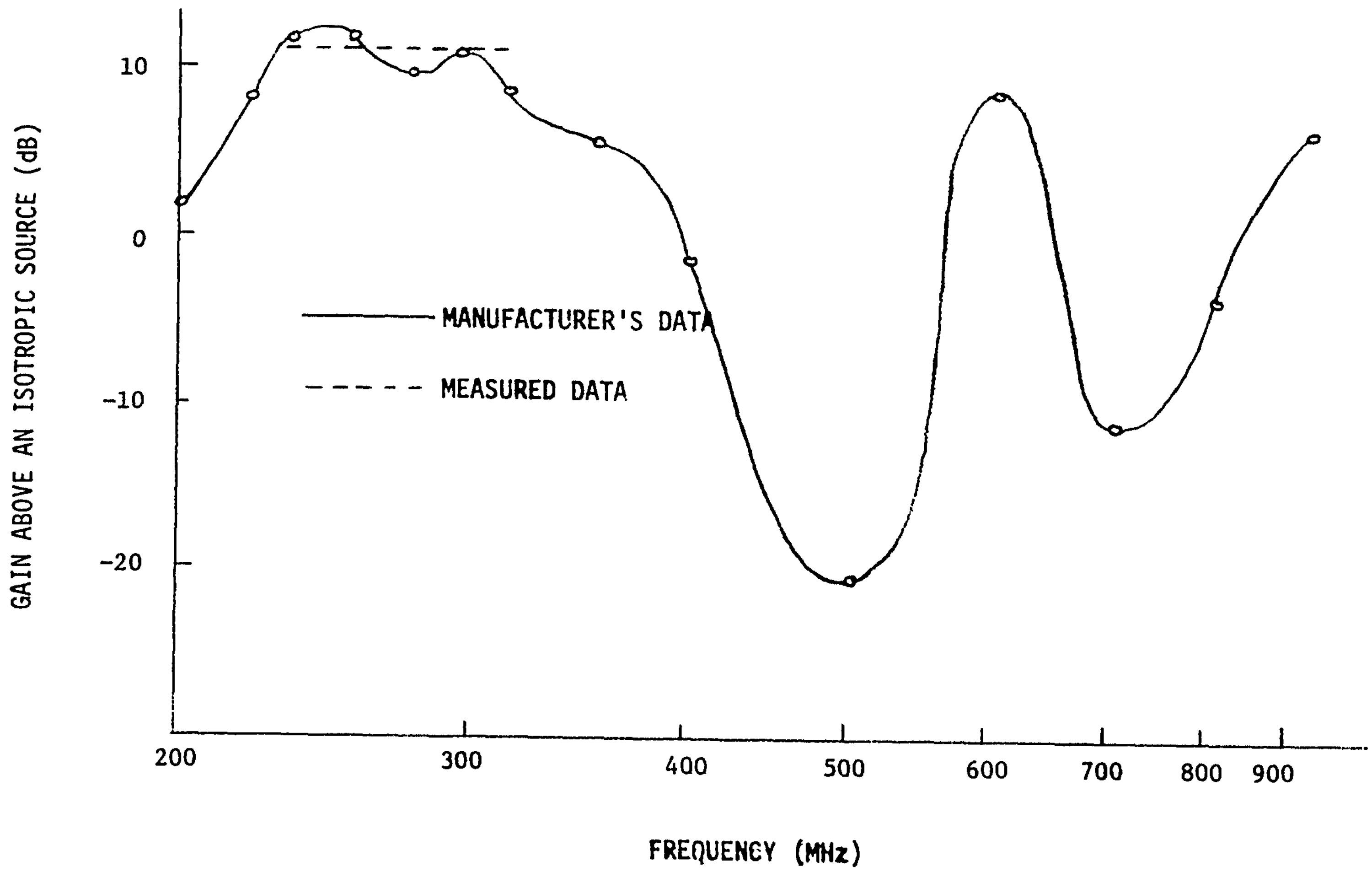


FIGURE 5. EXPERIMENTAL GAIN OF SATCOM ANTENNA COMPARED TO MANUFACTURER'S DATA

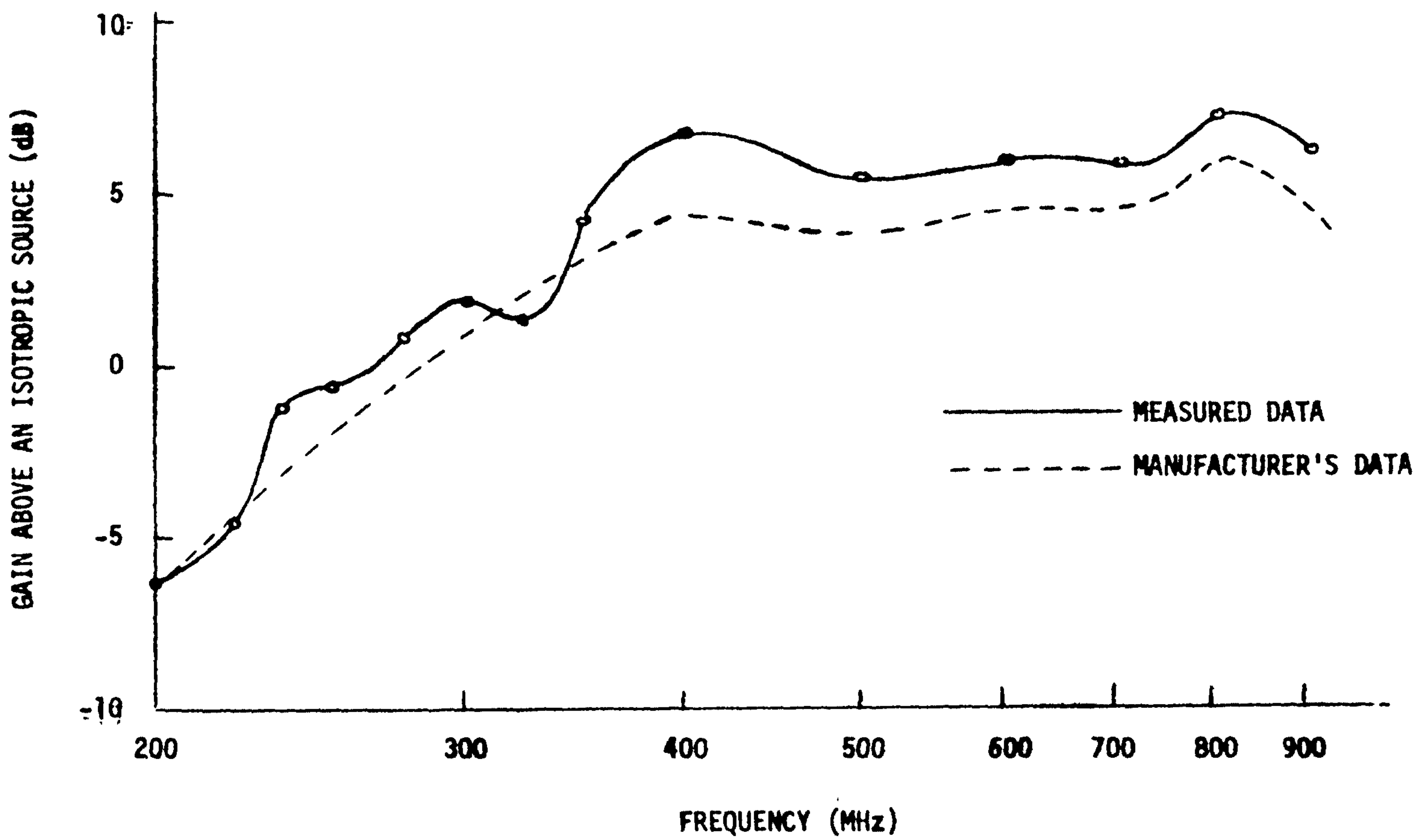


FIGURE 6. EXPERIMENTAL GAIN OF LOG CONICAL SPIRAL SHOWING MANUFACTURER'S DATA

Table 3 lists the 3 dB beamwidth and side-lobe level (main beam-to-largest lobe off main beam) at 0° elevation for the band of interest (200-900 MHz.) The patterns are shown in Figures 7 through 34. The 0 dB circle of each pattern plot represents some particular gain value with respect to an isotropic antenna, and is shown below each plot.

C. ELEVATION PATTERNS VS. FREQUENCY

The SATCOM antenna was oriented on the main beam in the azimuth plane and rocked back in elevation to obtain the patterns of Figures 35 through 37.

D. AXIAL RATIO VS. FREQUENCY

The <u>axial ratio</u> is defined as $|\overline{E}_{max}|/|\overline{E}_{min}|$ from Figure 38.

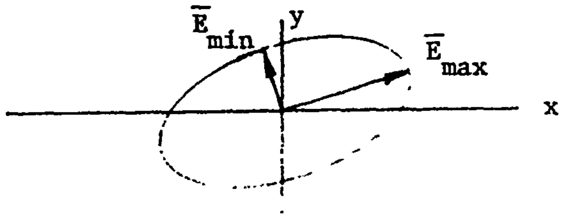
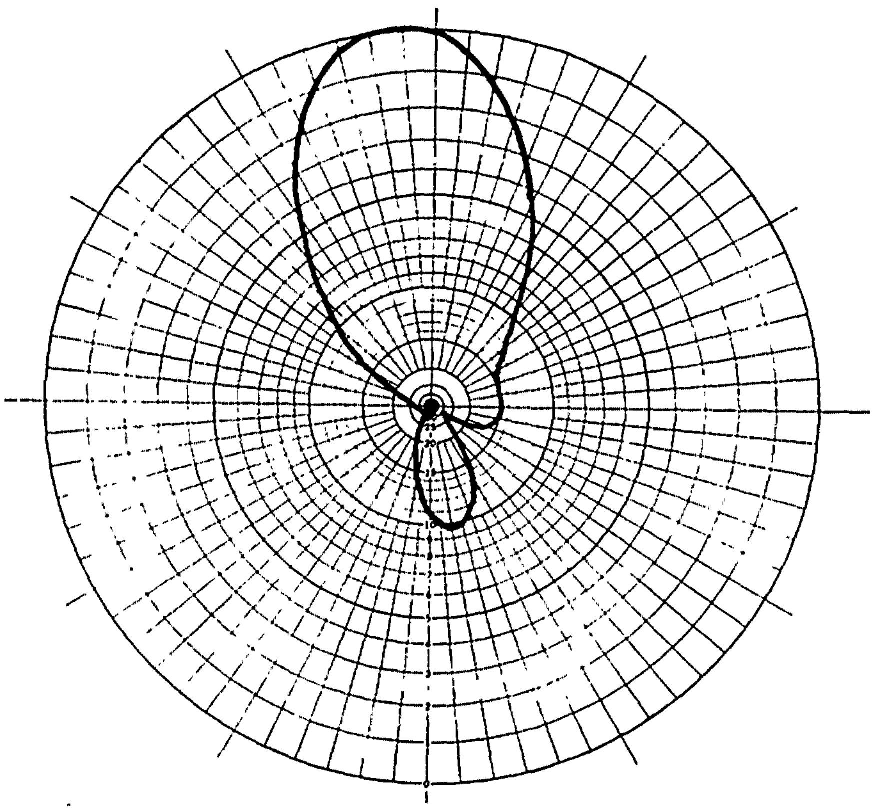


Figure 38.

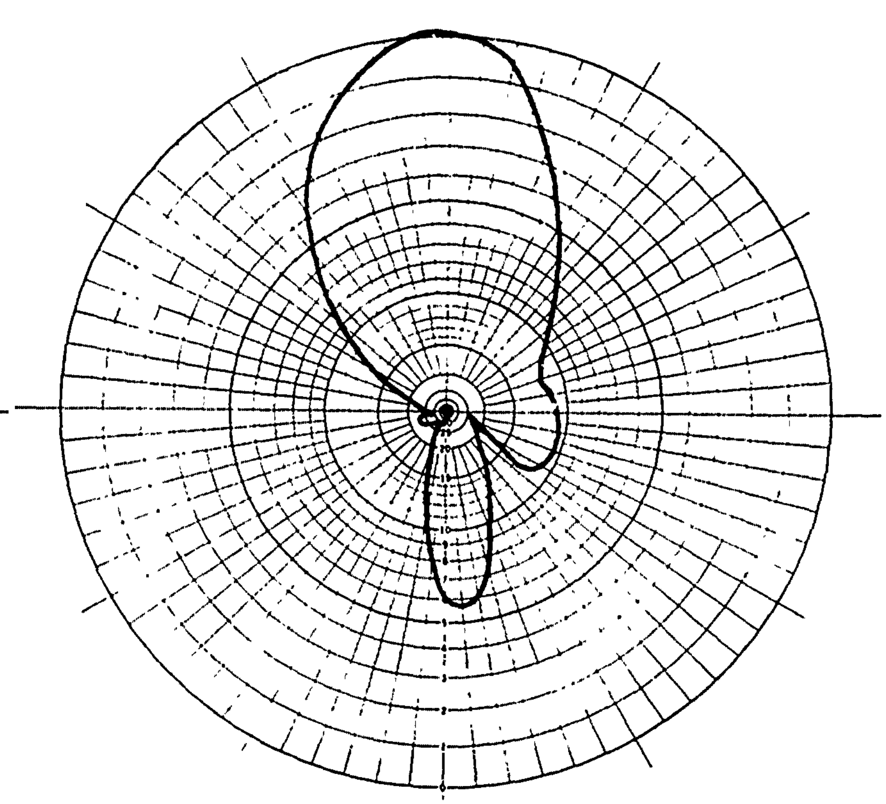
The $\overline{E}$'s represent the electric field strength. As previously mentioned, gain measurements also produce data to determine axial ratio. Tables 1 and 2 list max and min values whose ratios are quite different from 1.0 (corresponding to perfect circular polarization). Part of the reason for this is because of the reflected wave's effect on <u>ellipticity</u> or the deviation from pure circular polarization. For true CP, ellipticity is 0 dB. Figure 39 is from Reference 2 and illustrates that for the value of reflected/direct ray experienced (-15 dB) the ellipticity observed for true CP will degrade to 3 dB. Thus the "spread" of axial ratio as measured is ±3 dB. Figure 40 shows this for the SATCOM antenna and Figure 41 for the conical log spiral.

FREQUENCY (MHz)	3 dB BEAMWIDTH (°)	HIGHEST SIDE-LOBE (dB)
205	48	-9.5
225	40	-12.3
240	42	-7.3
260	54	-7.8
280	46	-9.3
300	46	-7.8
320	32	-2.8
360	26	+2.4
400	34	-2.2
500	26	-6.3
600	19	+1.0
700	15	-4.8
800	13	-8.2
900	12	-8.2

TABLE 3. 3 dB BEAMWIDTH AND SIDE LOBE LEVELS AT 0° ELEVATION FOR THE SATCOM ANTENNA.

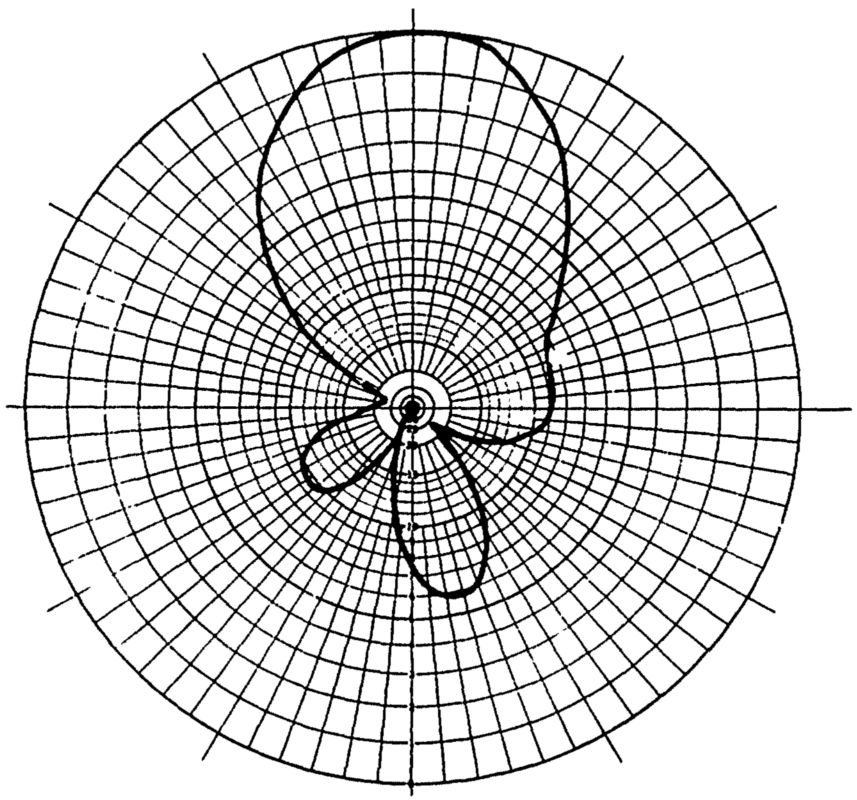


205 MHz, 0° Elevation,
0 = +2.6 db Above Isotropic
(+2.6 db_i)

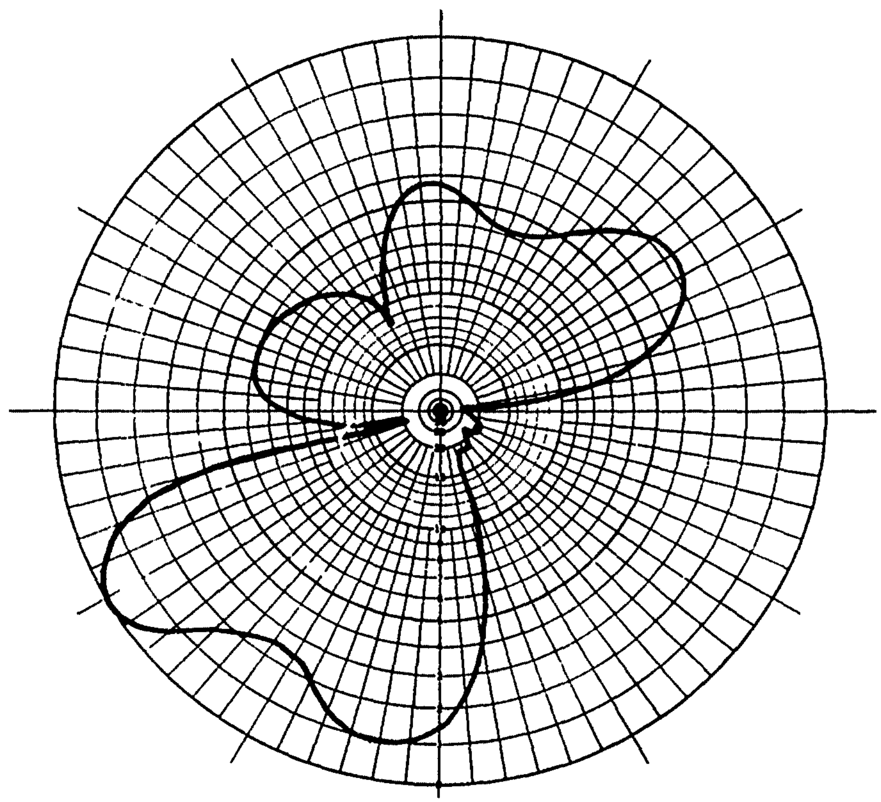


205 MHz, 10° Elevation,
0 = +2.6 db_i

Figure 7. Polar Patterns for the SATCOM Antenna

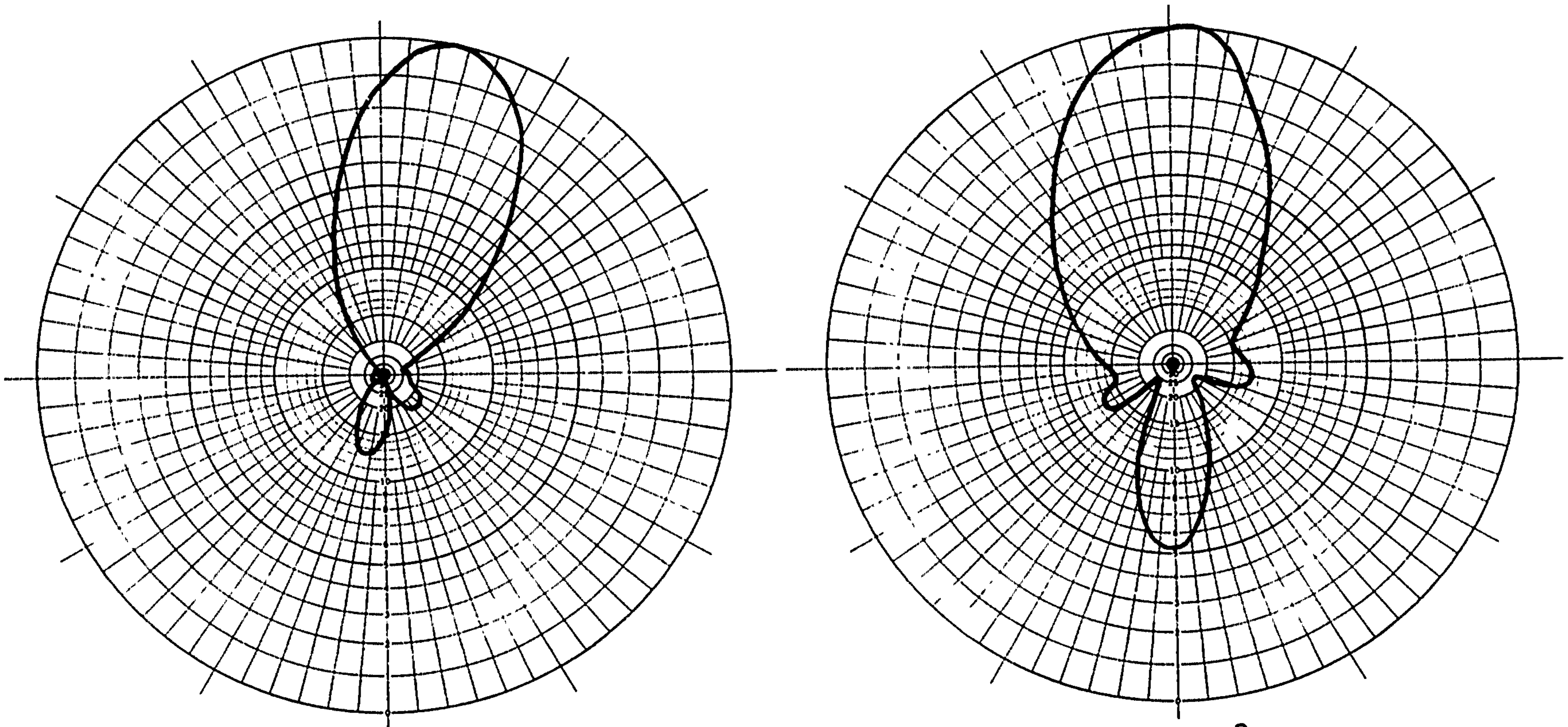


205 MHz, 50° Elevation
$0 = -4.4\ db_i$



205 MHz, 90° Elevation
$0 = -0.4\ db_i$

Figure 8. Polar Patterns for the SATCOM Antenna



225 MHz, 0° Elevation
$0 = +8.7\ db_i$

225 MHz, 10° Elevation
$0 = +8.2\ db_i$

Figure 9. Polar Patterns for the SATCOM Antenna

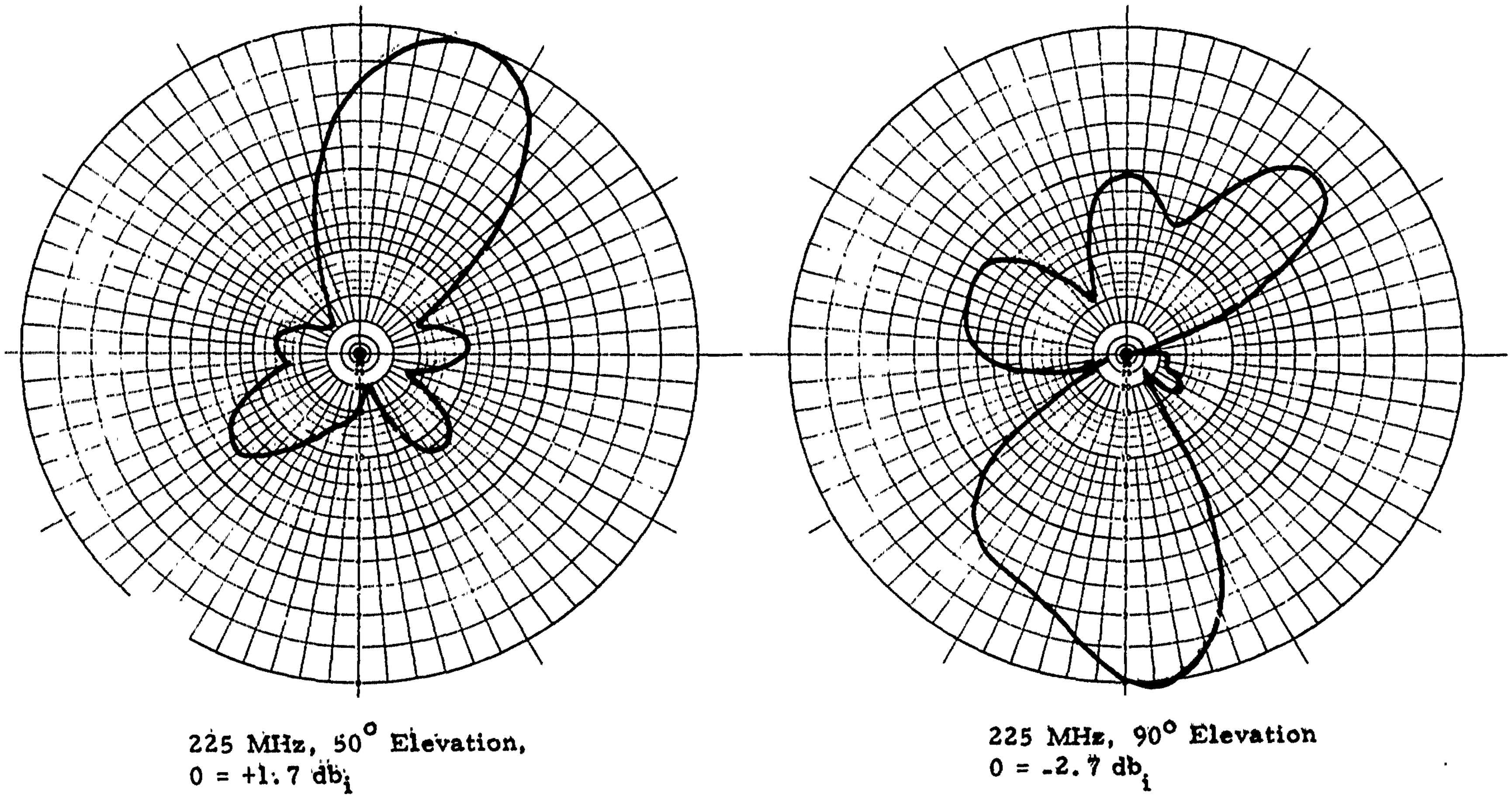
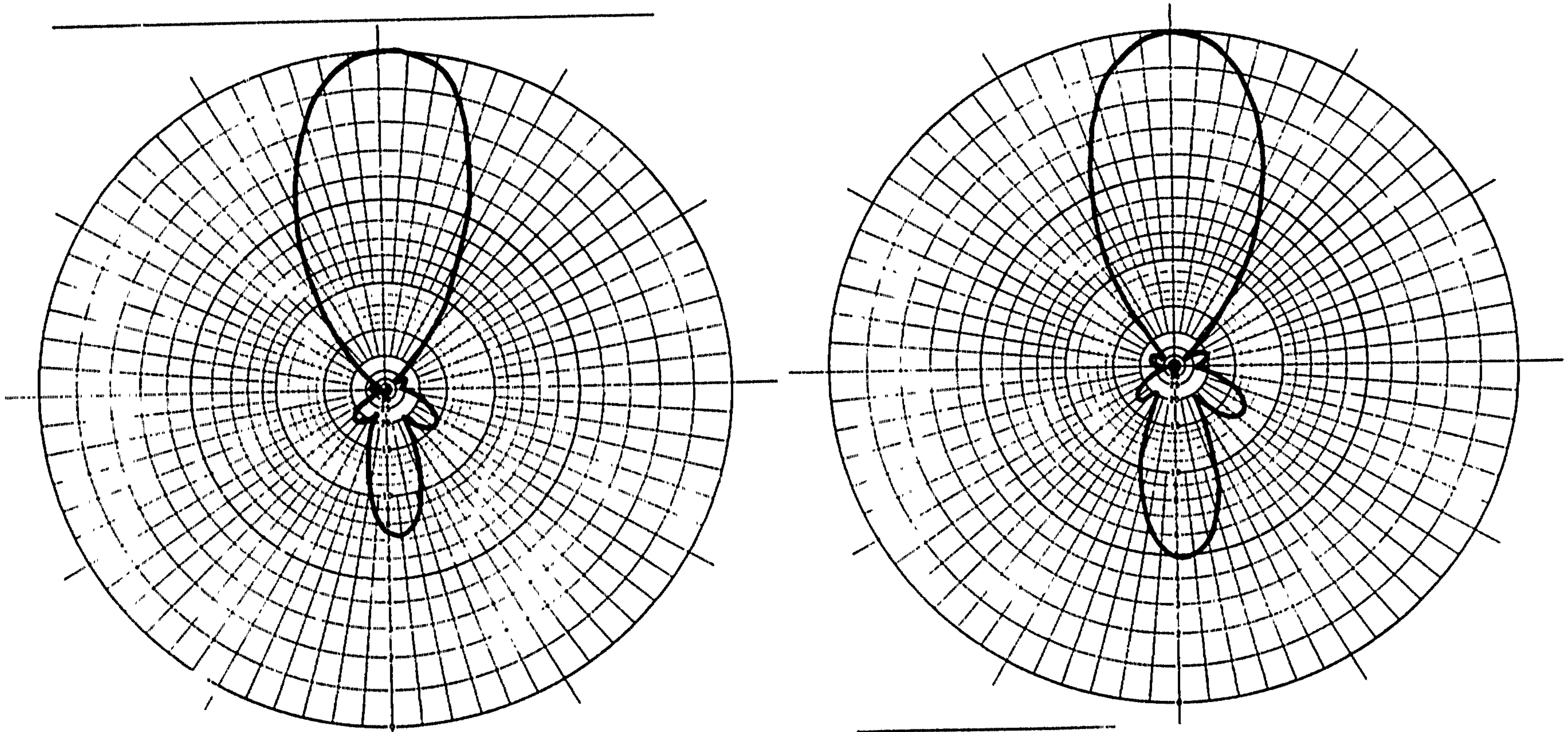


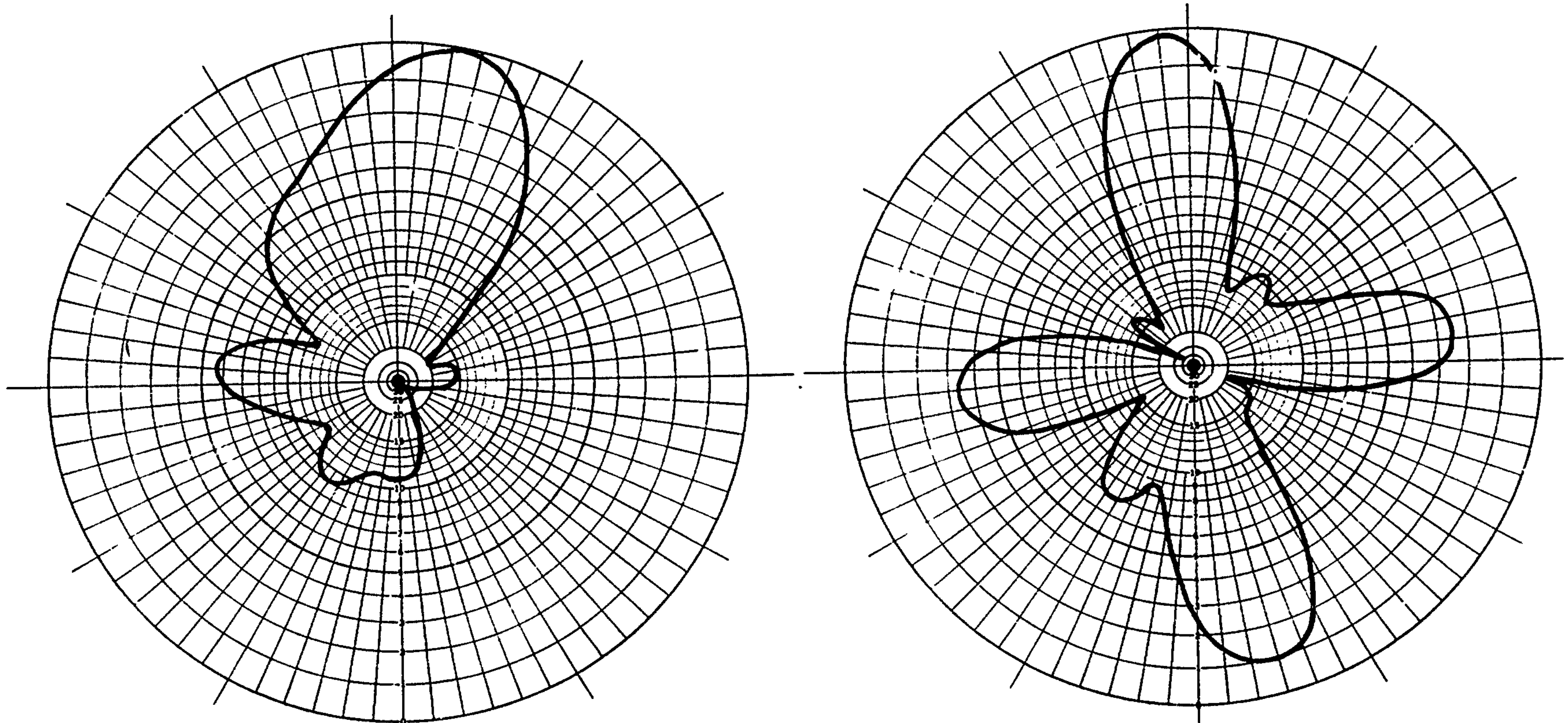
Figure 10. Polar Patterns for the SATCOM Antenna



240 MHz, 0^{o} Elevation,
$0=+12\ db_i$

240 MHz, 10^{o} Elevation
$0 = +11db_i$

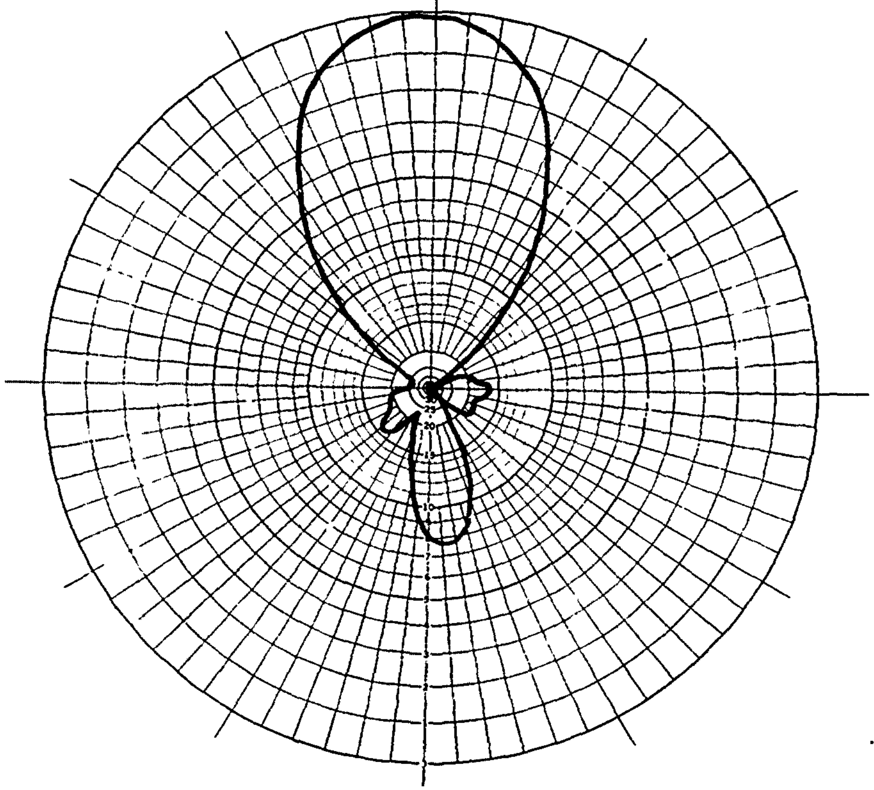
Figure 11. Polar Patterns for the SATCOM Antenna



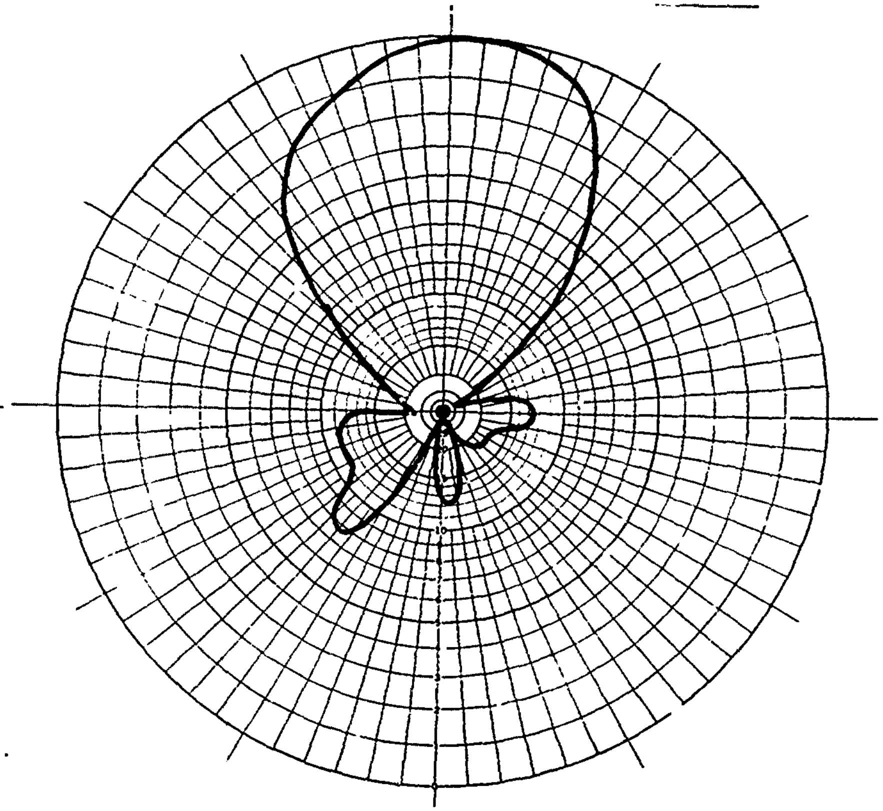
240 MHz, 50^{o} Elevation,
$0 = 0\ db_i$

240 MHz, 90^{o} Elevation,
$0 = -6\ db_i$

Figure 12. Polar Patterns for the SATCOM Antenna

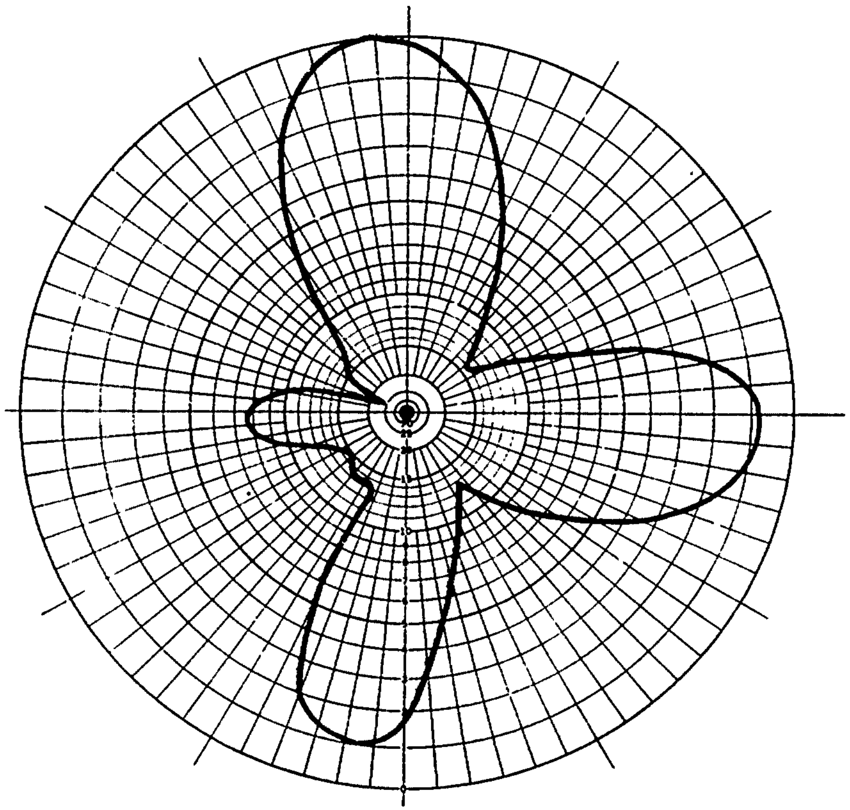


260 MHz, 0^{o} Elevation
$0 = +12.9\ db_i$

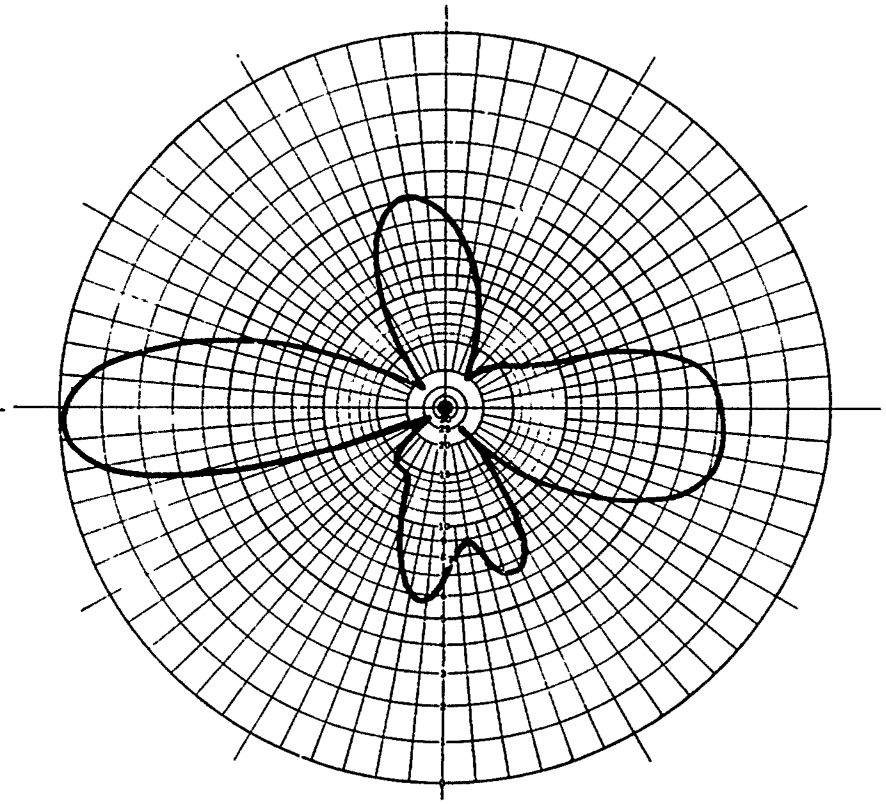


260 MHz, 10^{o} Elevation
$0 = +9.9\ db_i$

Figure 13. Polar Patterns for the SATCOM Antenna

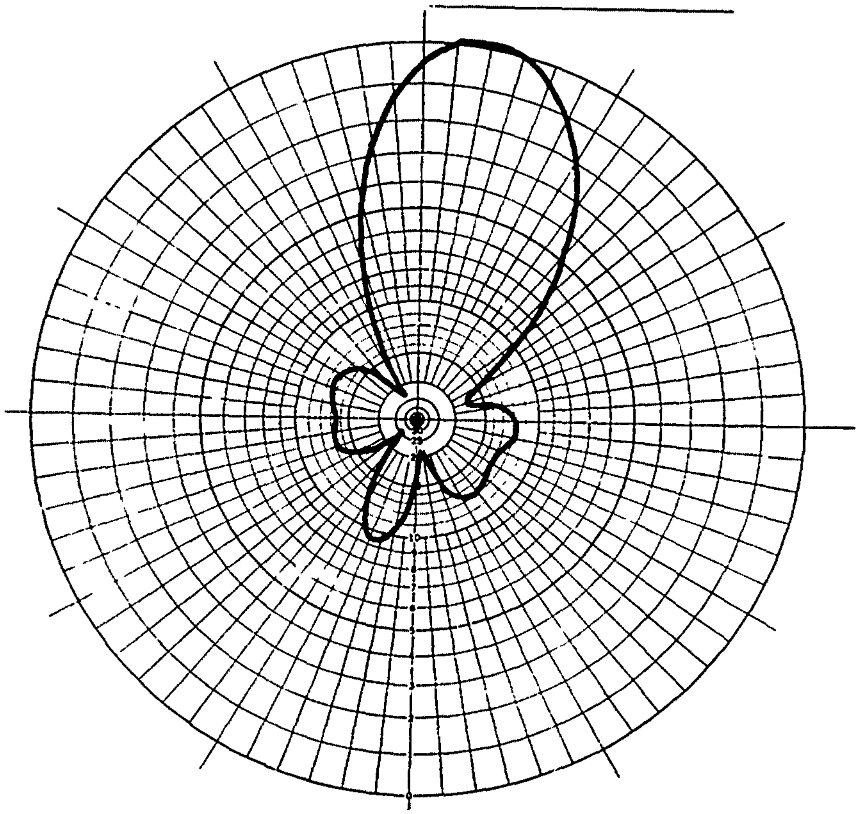


260 MHz, 50° Elevation,
0 = -3.9 db_i

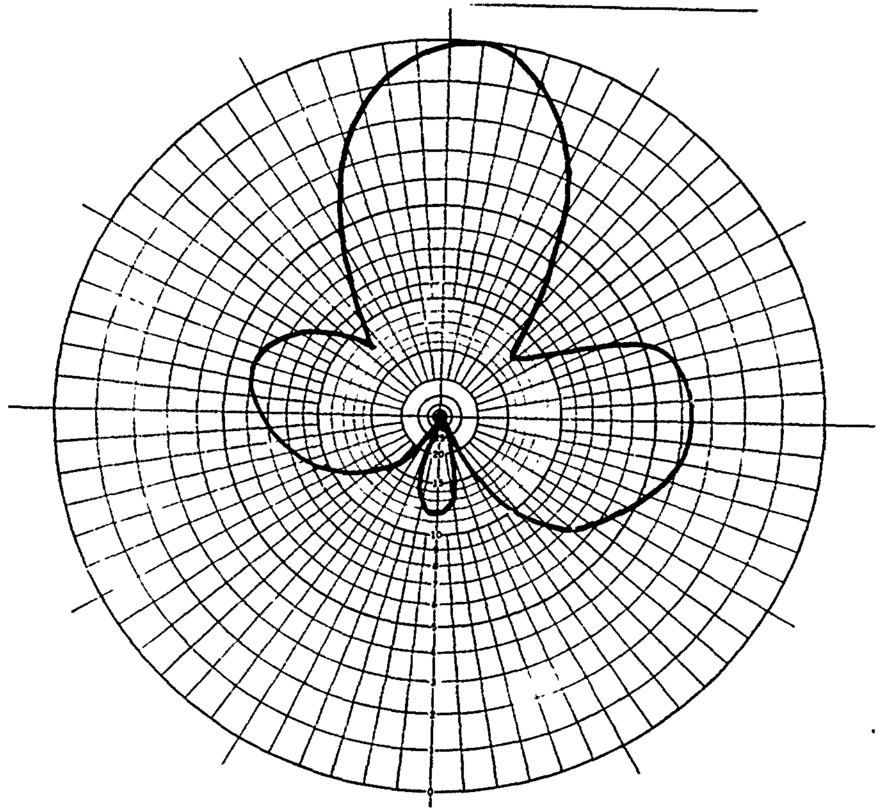


260 MHz, 90° Elevation,
0 = -11.9 db_i

Figure 14. Polar Patterns for the SATCOM Antenna

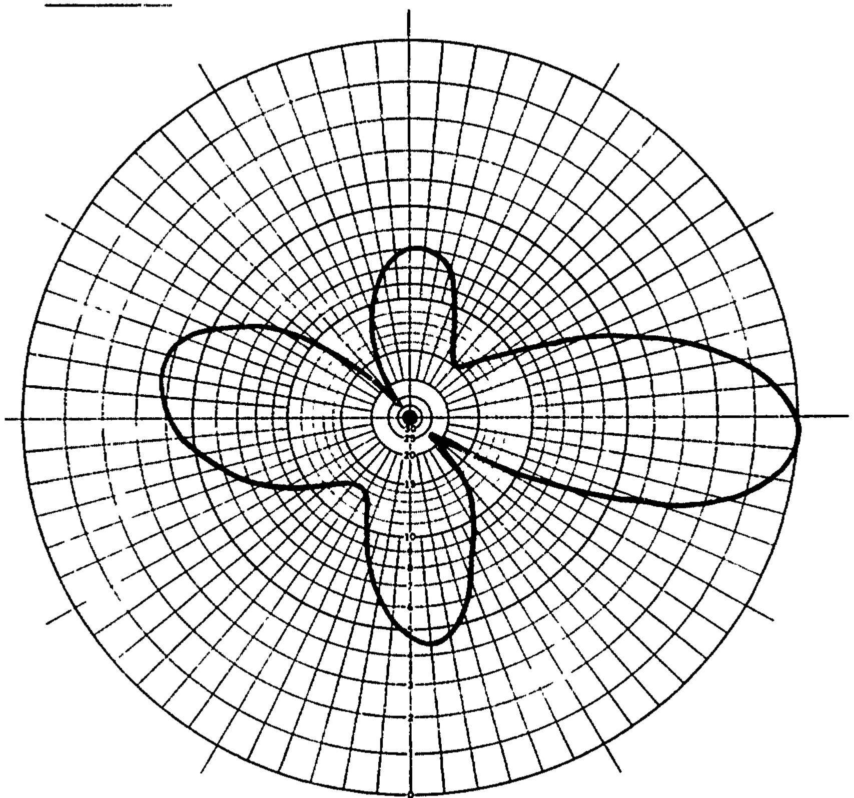


280 MHz, 0^{o} Elevation,
$0 = +9.5\ db_i$

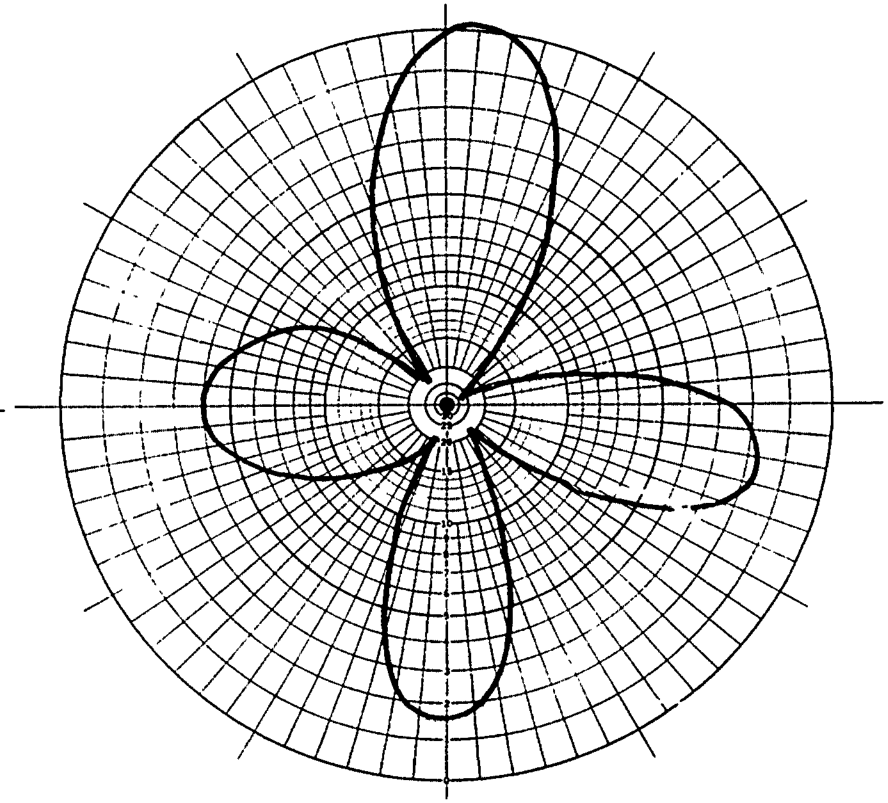


280 MHz, 10^{o} Elevation
$0 = +6.5\ db_i$

Figure 15. Polar Patterns for the SATCOM Antenna

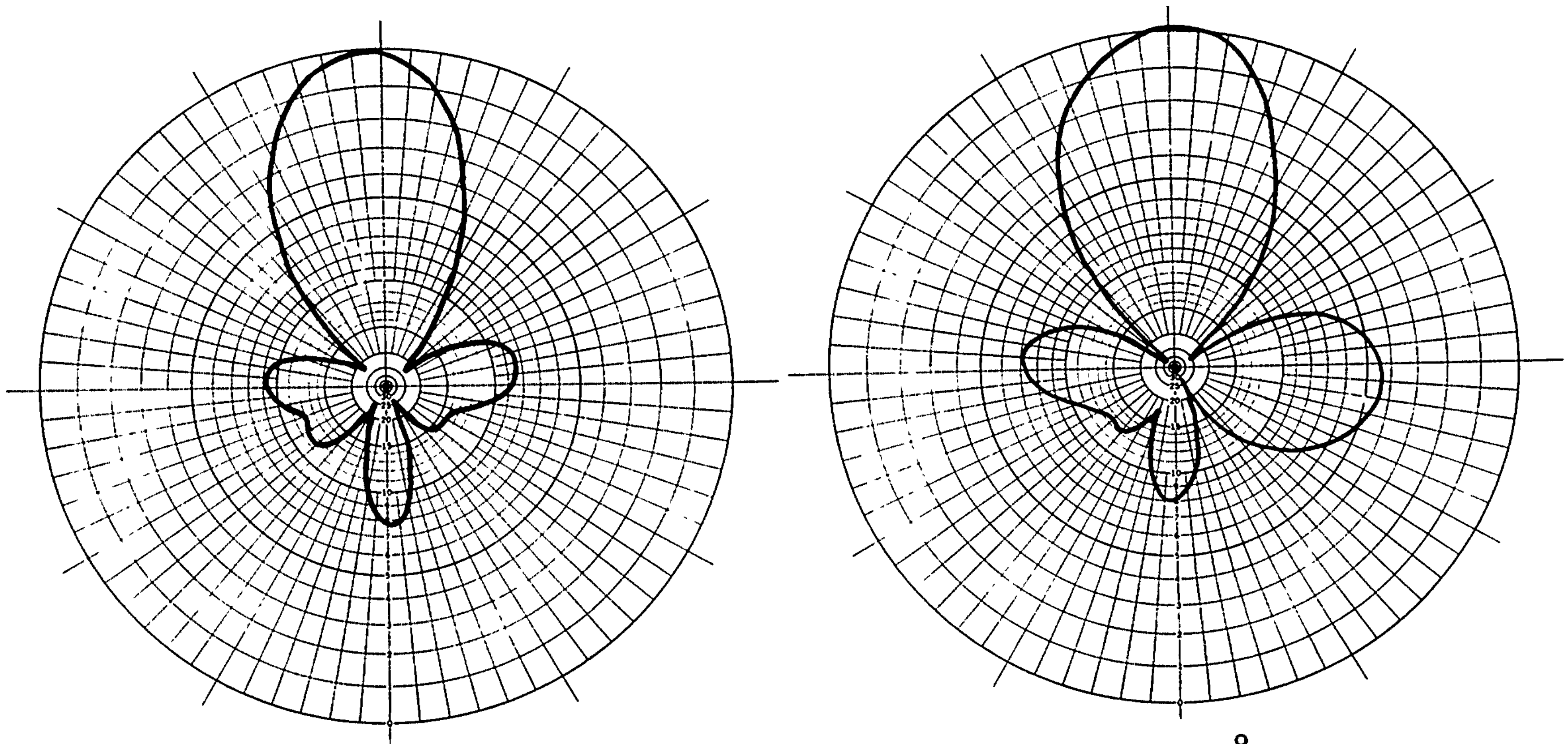


280 MHz, 50° Elevation,
0 = +3.5 db_i



280 MHz, 90° Elevation,
0 = +1.5 db_i

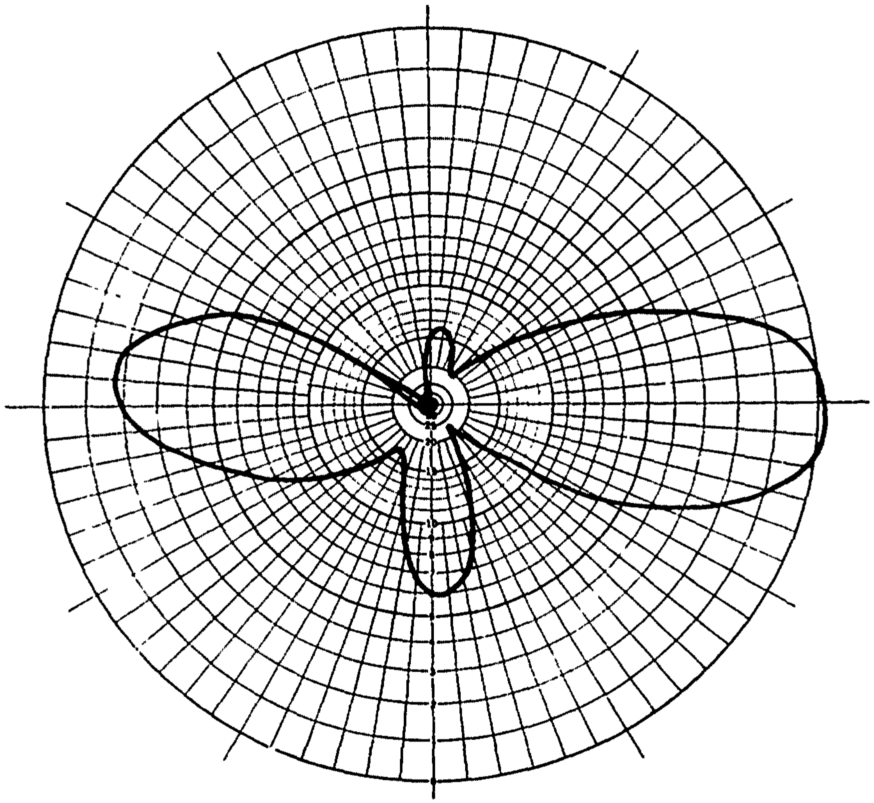
Figure 16. Polar Patterns for the SATCOM Antenna



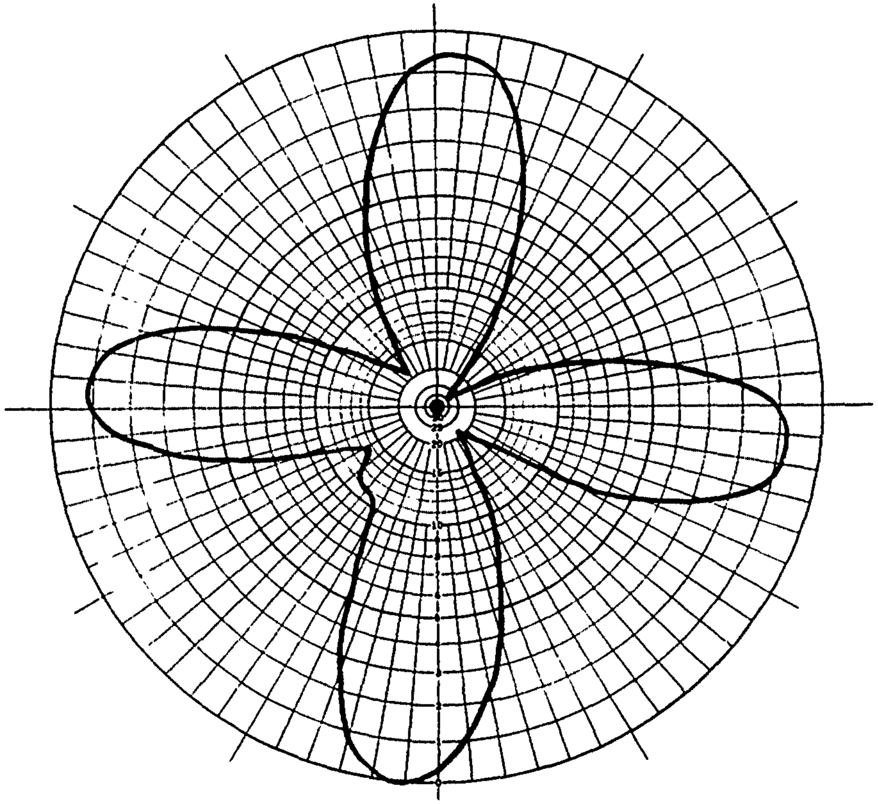
300 MHz, 0° Elevation,
$0 = +11.5\ db_i$

300 MHz, 10° Elevation
$0 = +8.5\ db_i$

Figure 17. Polar Patterns for the SATCOM Antenna

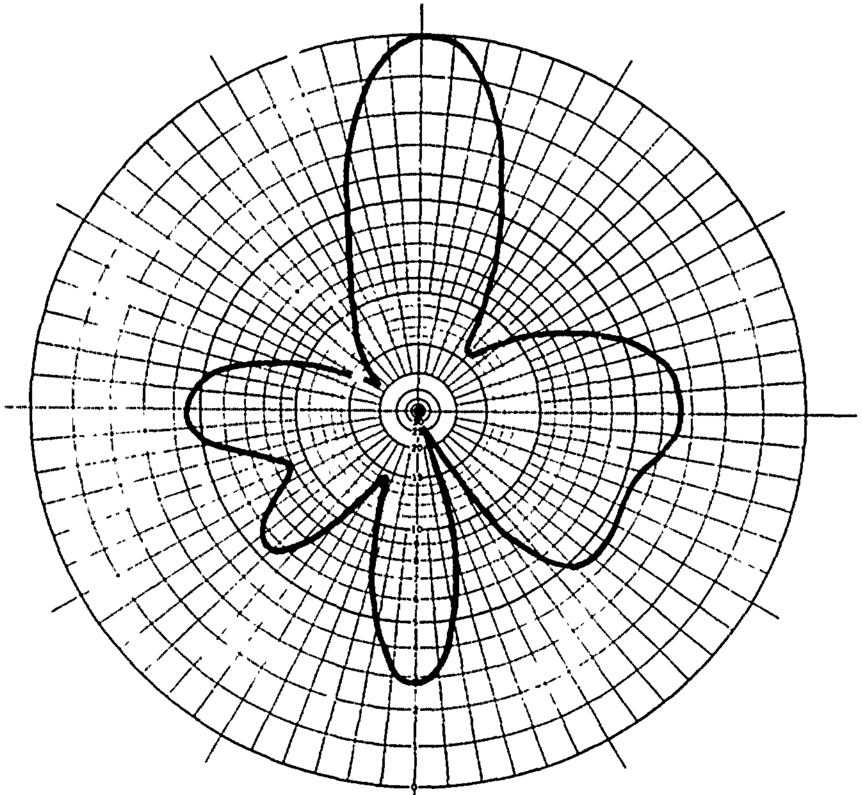


300 MHz, 50^{o} Elevation,
$0 = +1.5\ db_i$

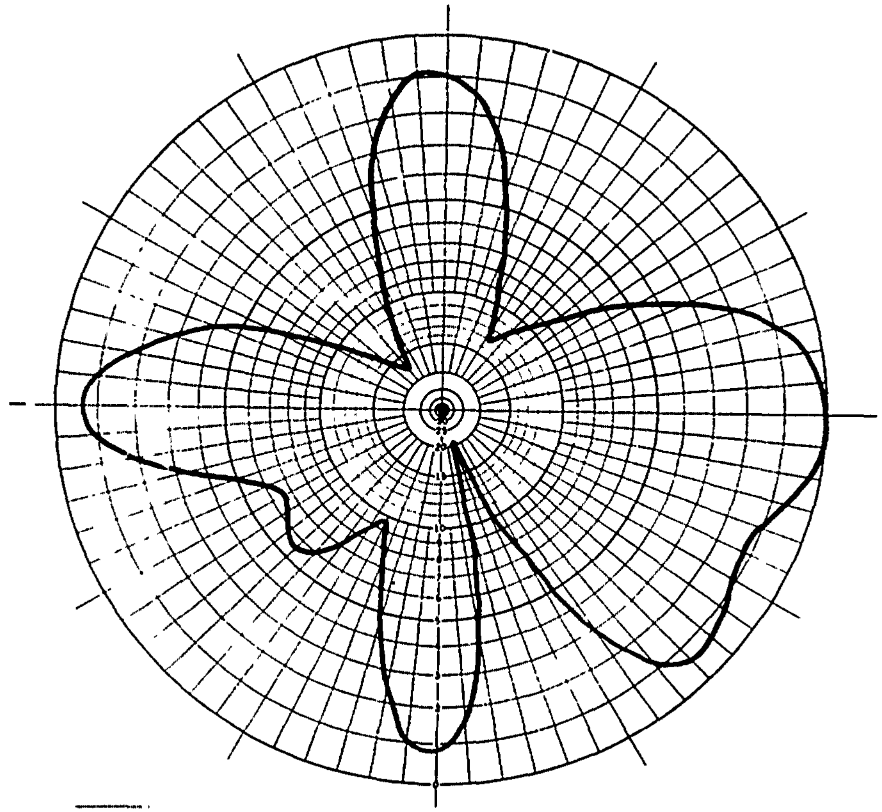


300 MHz, 90^{o} Elevation,
$0 = +1.5\ db_i$

Figure 18. Polar Patterns for the SATCOM Antenna

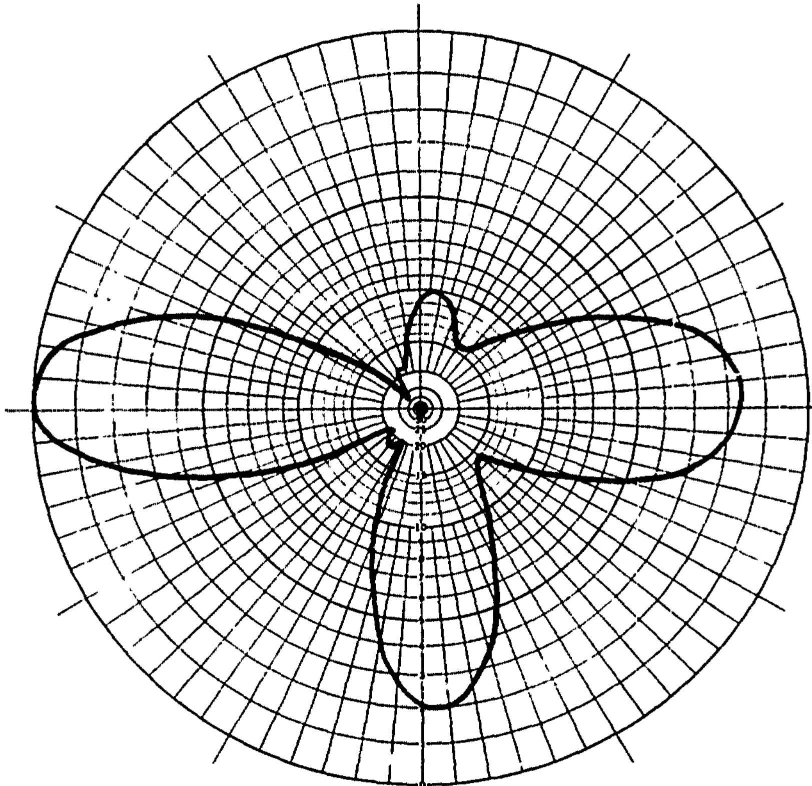


320 MHz, 0° Elevation,
0 = +9.5 db_i

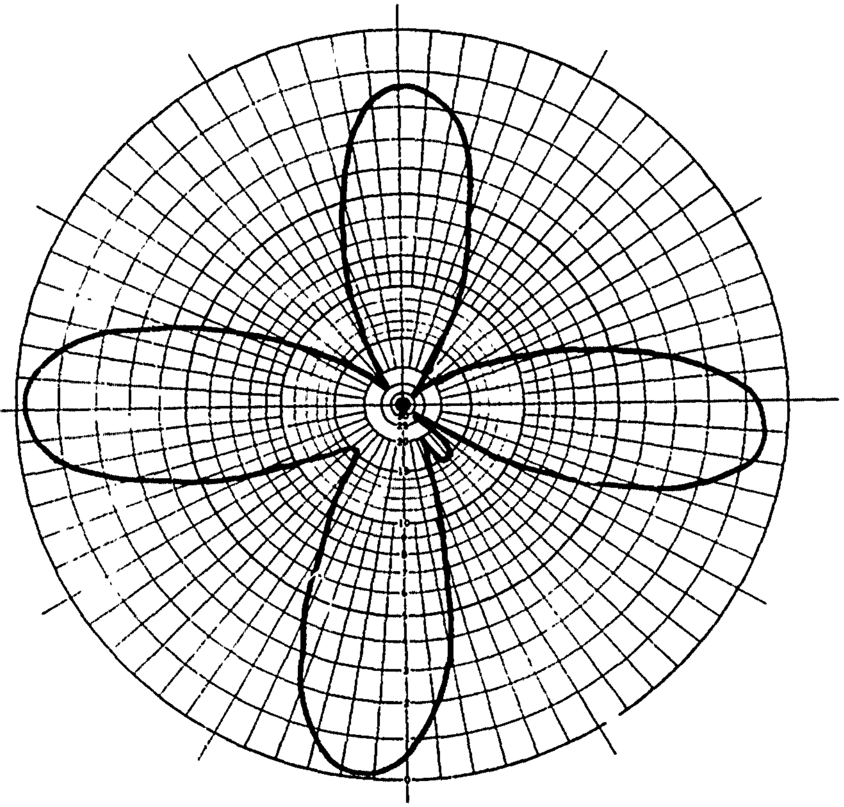


320 MHz, 10° Elevation
0 = +9.5 db_i

Figure 19. Polar Patterns for the SATCOM Antenna

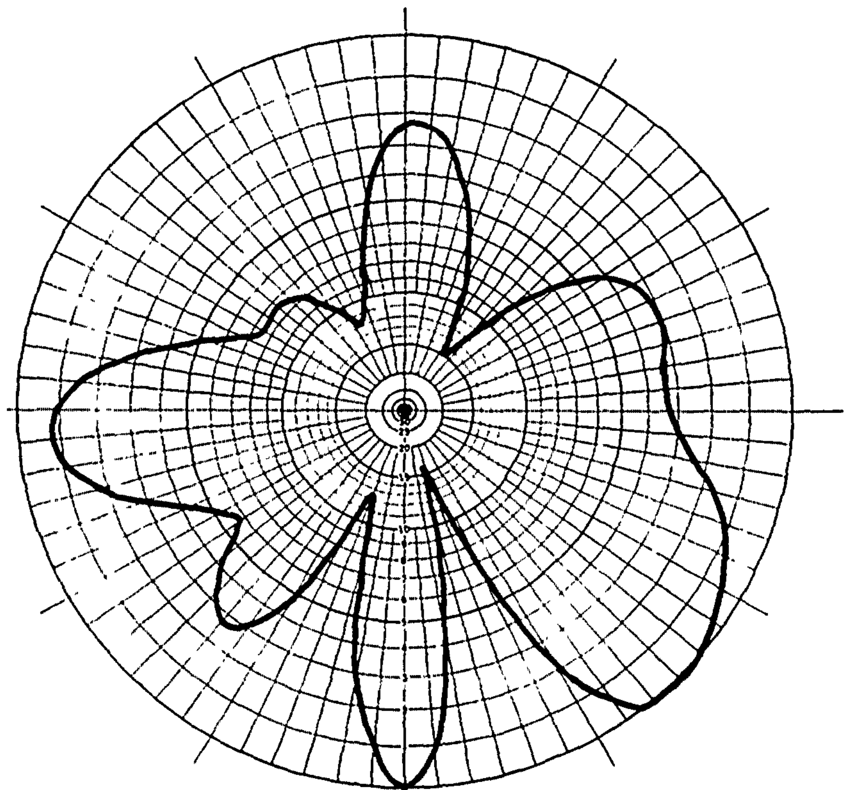


320 MHz, 50^{o} Elevation,
$0 = +10.5$ db_i

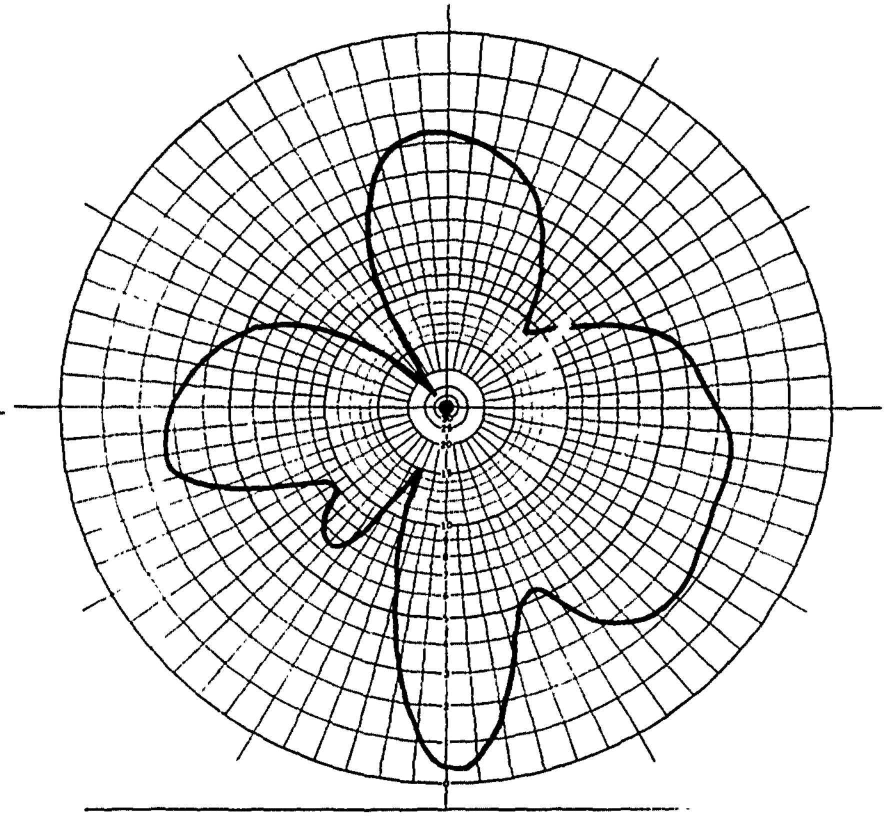


320 MHz, 90^{o} Elevation,
$0 = +13.5$ db_i

Figure 20. Polar Patterns for the SATCOM Antenna

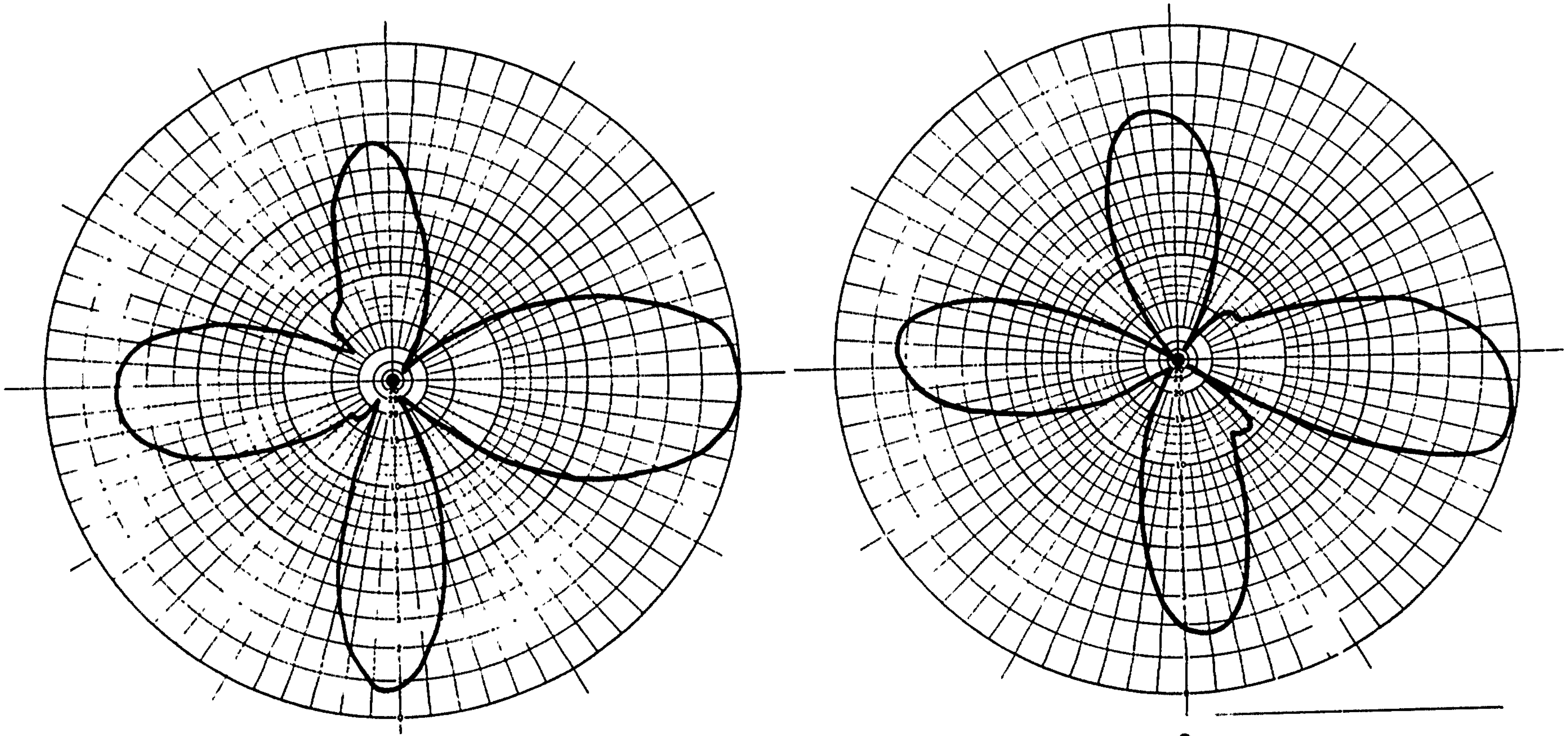


360 MHz, 0° Elevation,
$0 = +9.1\ db_i$



360 MHz, 10° Elevation,
$0 = +9.1\ db_i$

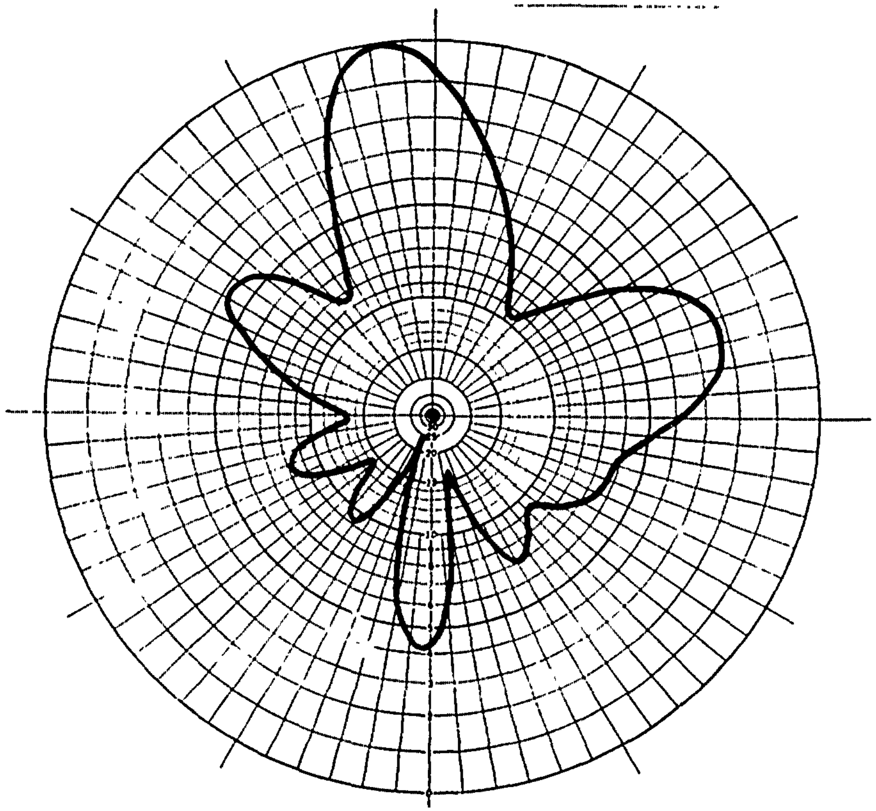
Figure 21. Polar Patterns for the SATCOM Antenna



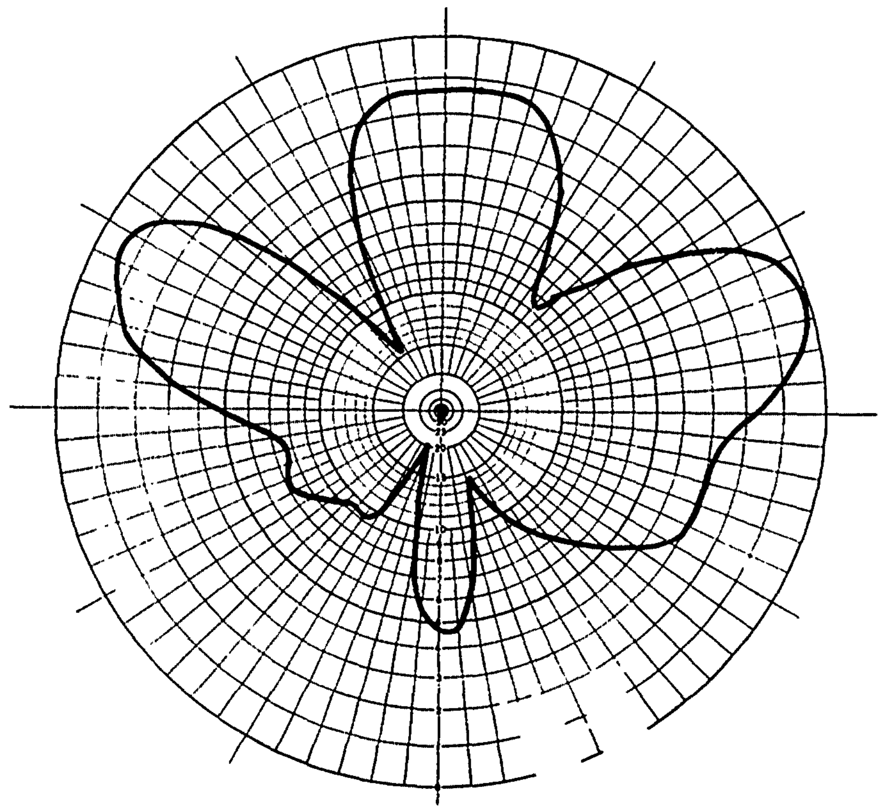
360 MHz, 50^{o} Elevation, $0 = +5.1\ db_i$

360 MHz, 90^{o} Elevation, $0 = +8.1\ db_i$

Figure 22. Polar Patterns for the SATCOM Antenna

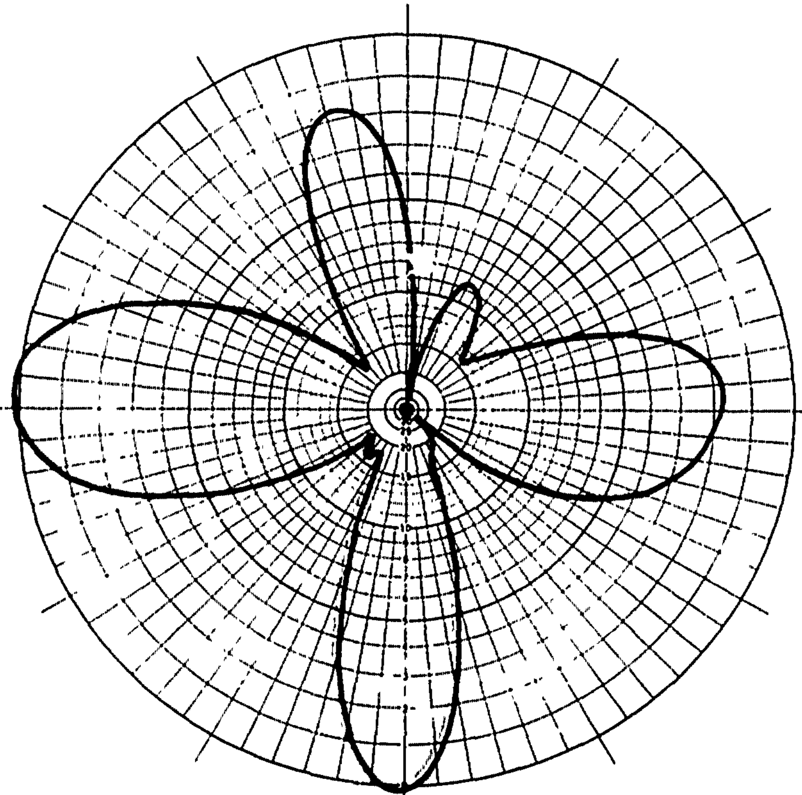


400 MHz, 0° Elevation,
0 = -1.3 db_i

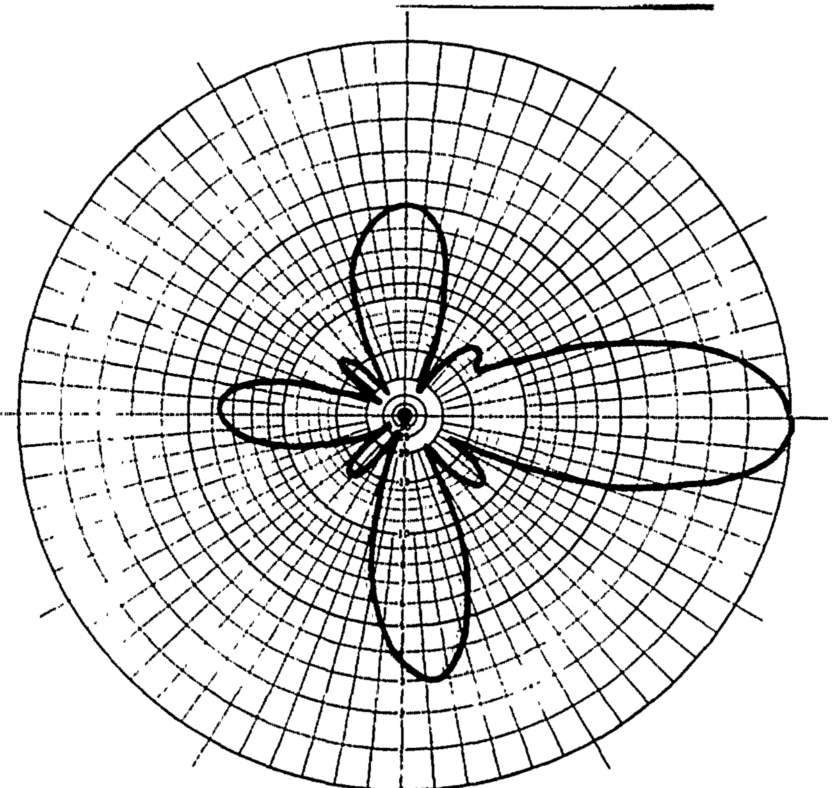


400 MHz, 10° Elevation,
0 = -3.3 db_i

Figure 23. Polar Patterns for the SATCOM Antenna

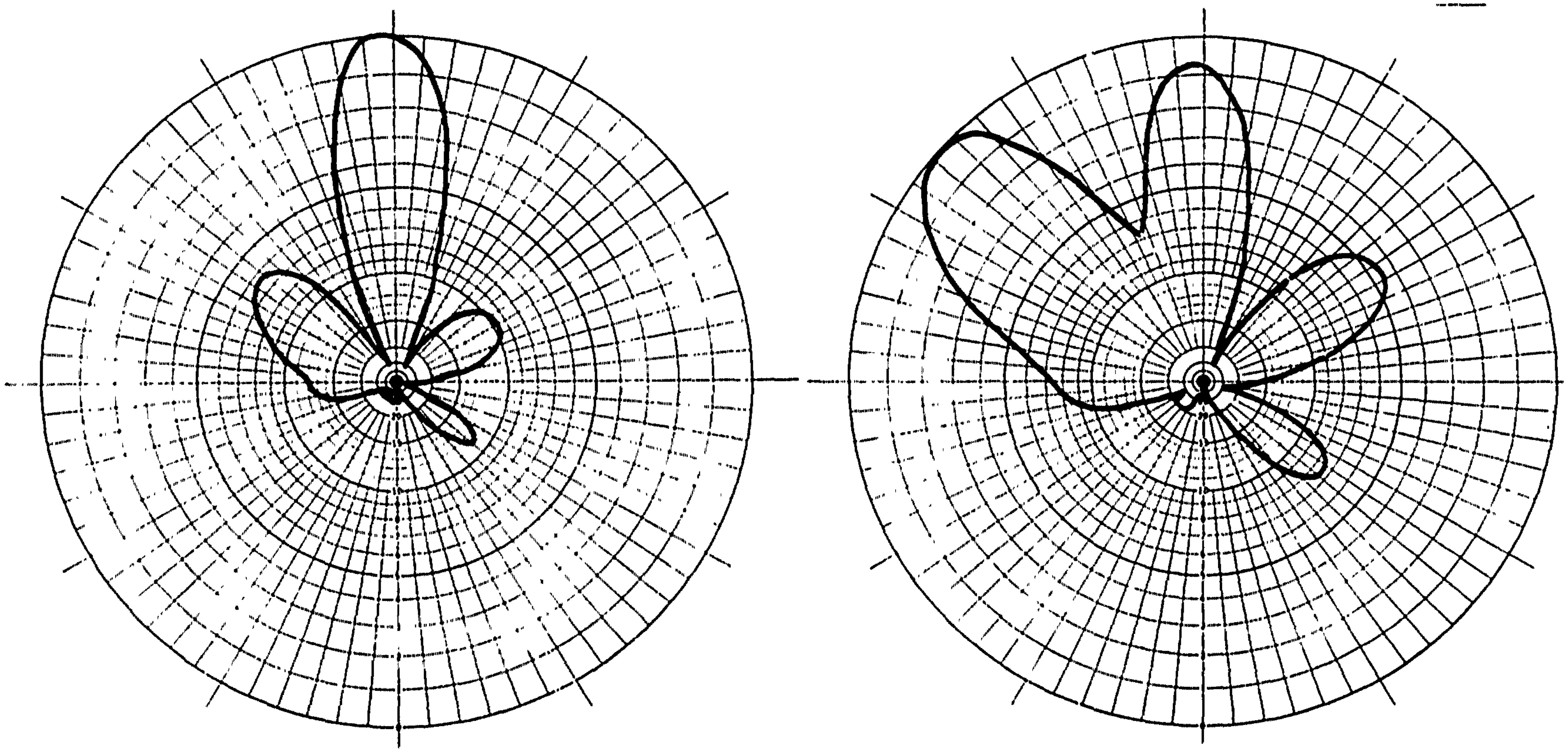


400 MHz, 50° Elevation,
0 = -5.3 db_i



400 MHz, 90° Elevation
0 = -4.3 db_i

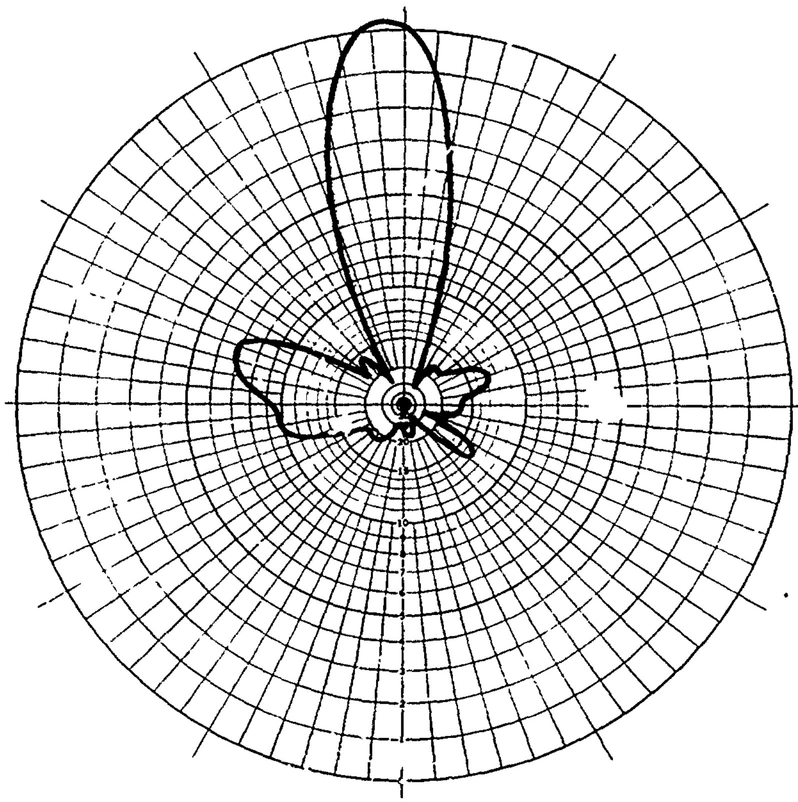
Figure 24. Polar Patterns for the SATCOM Antenna



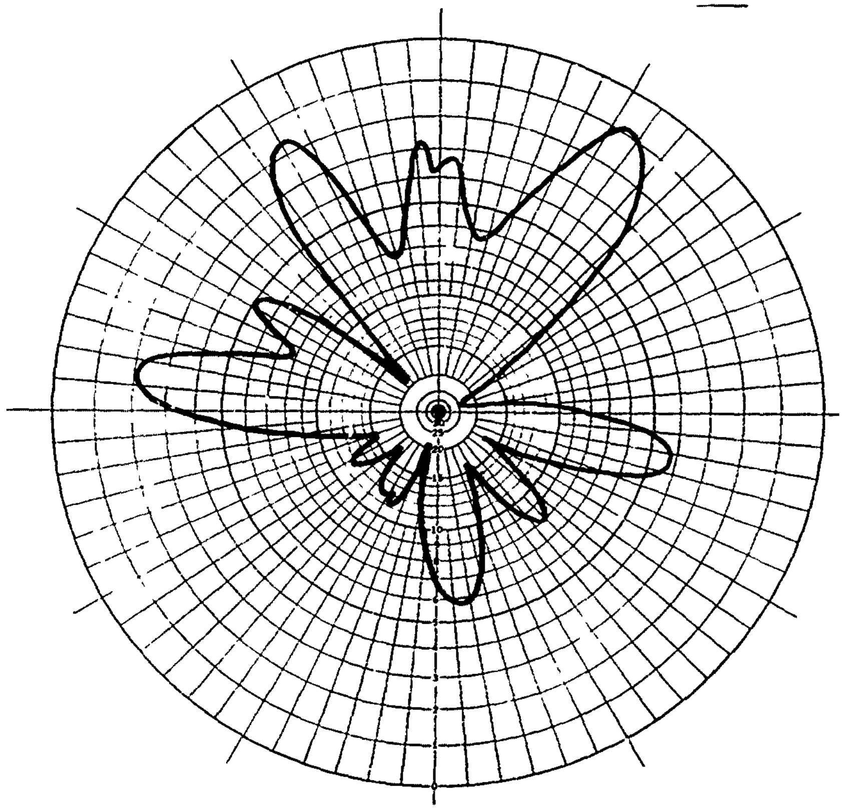
500 MHz, 0° Elevation,
$0 = -19.8\ db_i$

500 MHz, 10° Elevation,
$0 = -21.8\ db_i$

Figure 25. Polar Patterns for the SATCOM Antenna

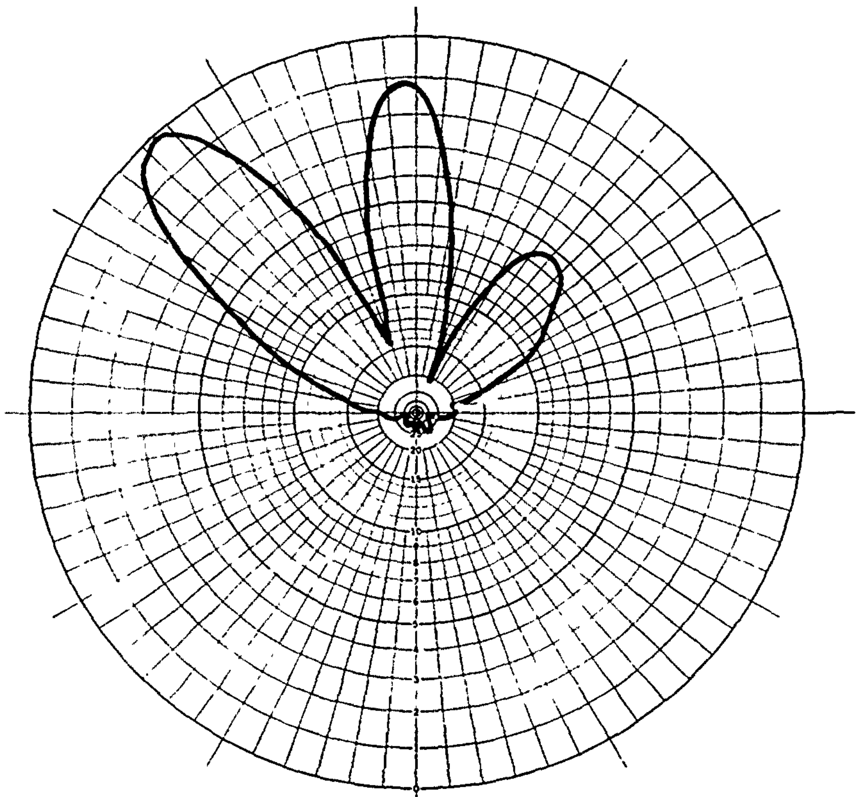


500 MHz, 50° Elevation,
0 = -27.8 db_i

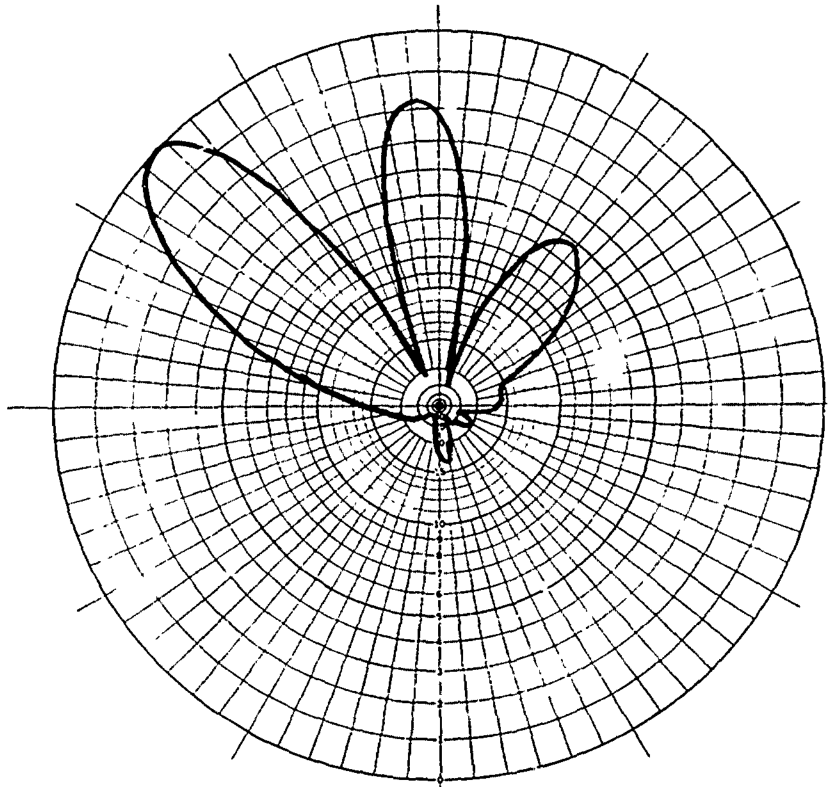


500 MHz, 90° Elevation,
0 = -27.8 db_i

Figure 26. Polar Patterns for the SATCOM Antenna

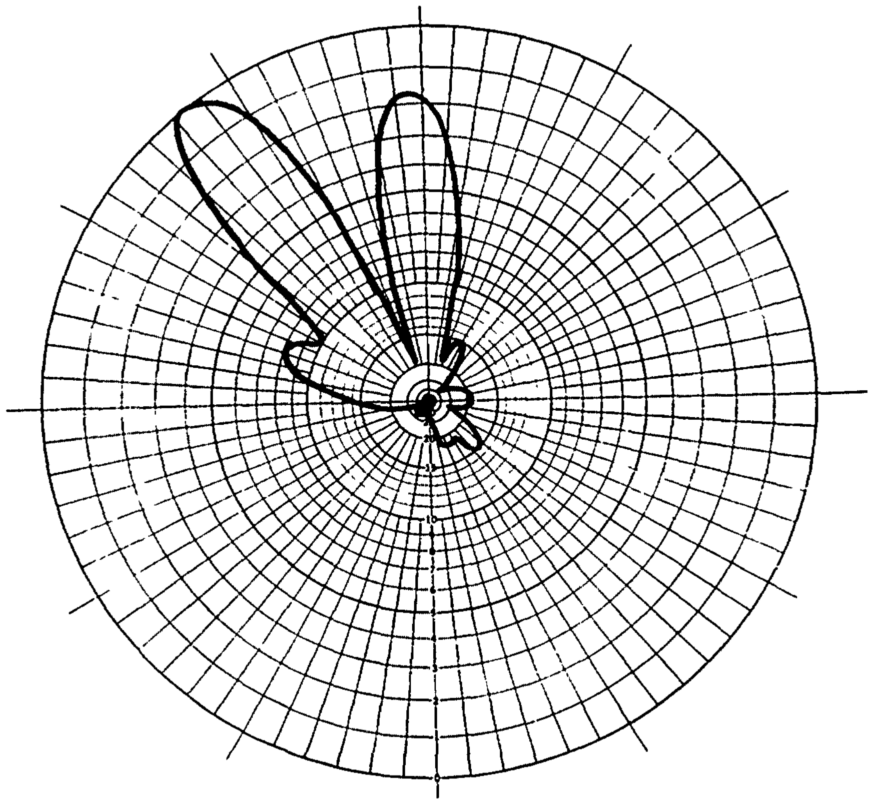


600 MHz, 0^{o} Elevation,
0 = +10.5 db_i

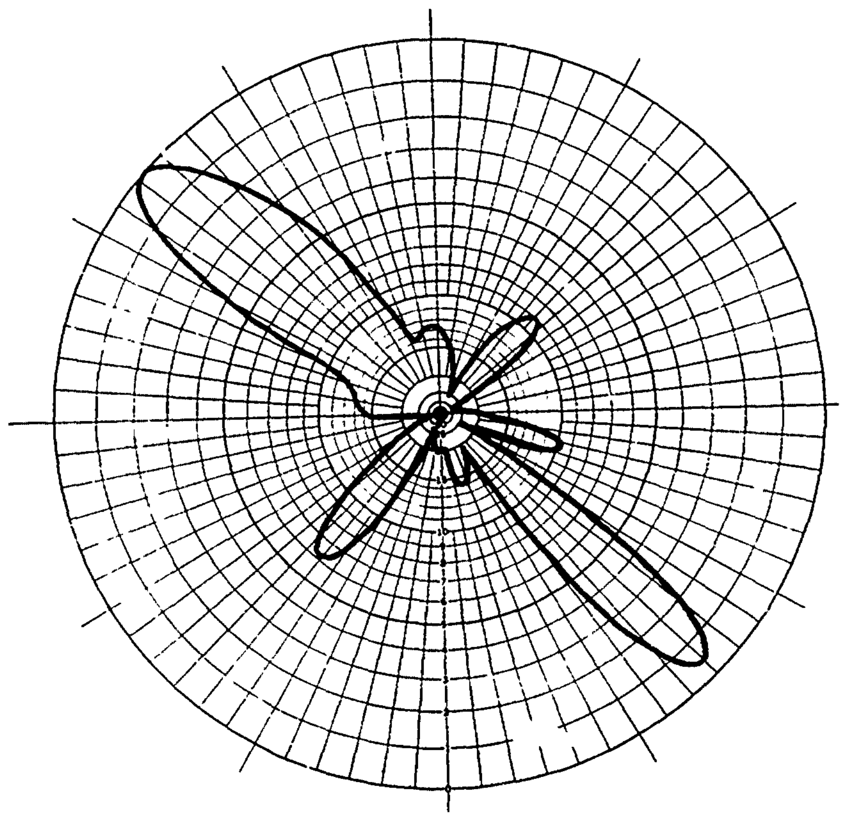


600 MHz, 10^{o} Elevation,
0 = +10.5 db_i

Figure 27. Polar Patterns for the SATCOM Antenna

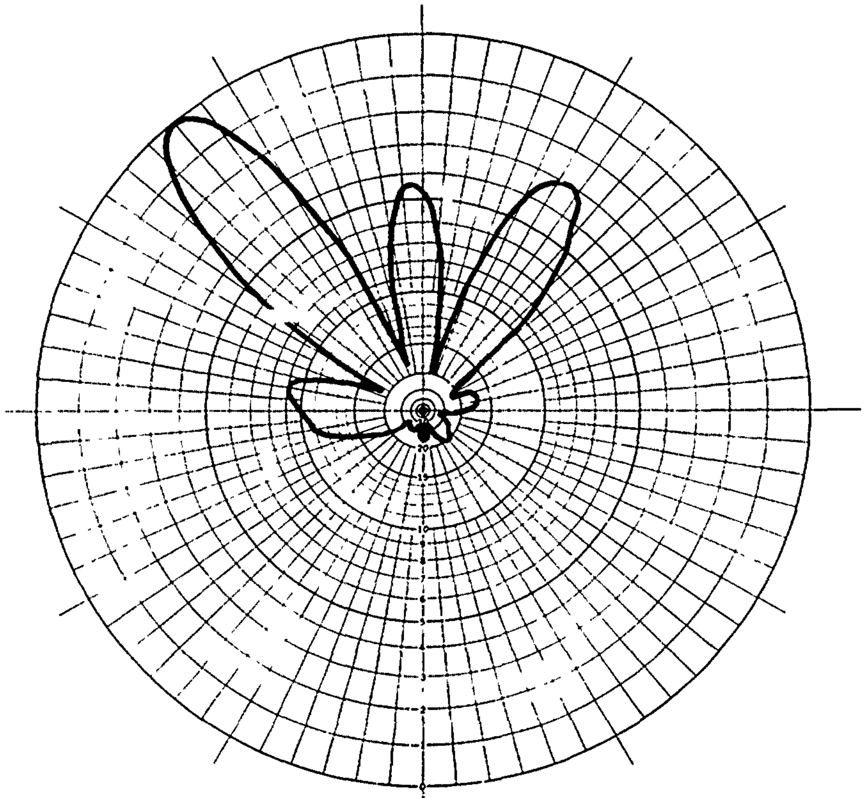


600 MHz, 50° Elevation,
0 = +9.5 db_i

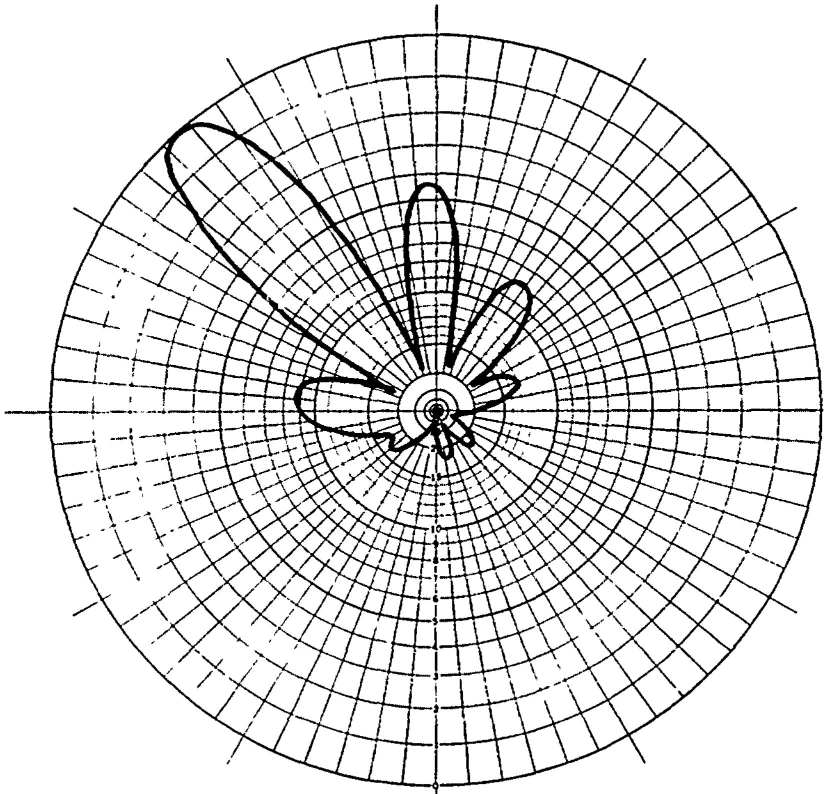


600 MHz, 90° Elevation,
0 = +4.5 db_i

Figure 28. Polar Patterns for the SATCOM Antenna

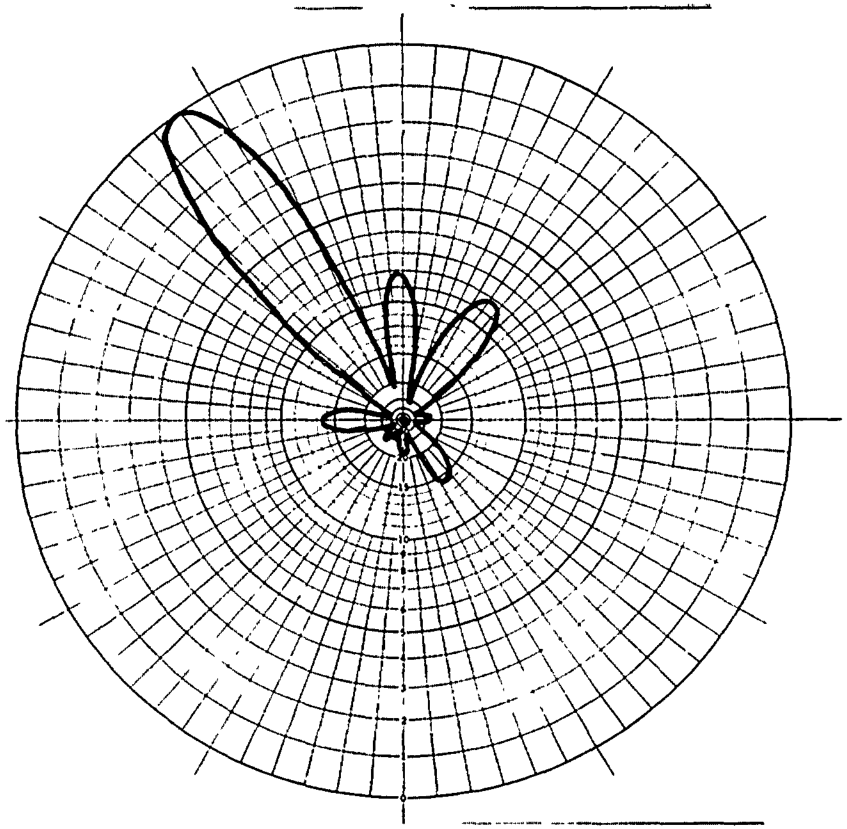


700 MHz, 0° Elevation
0 = -6 db_i

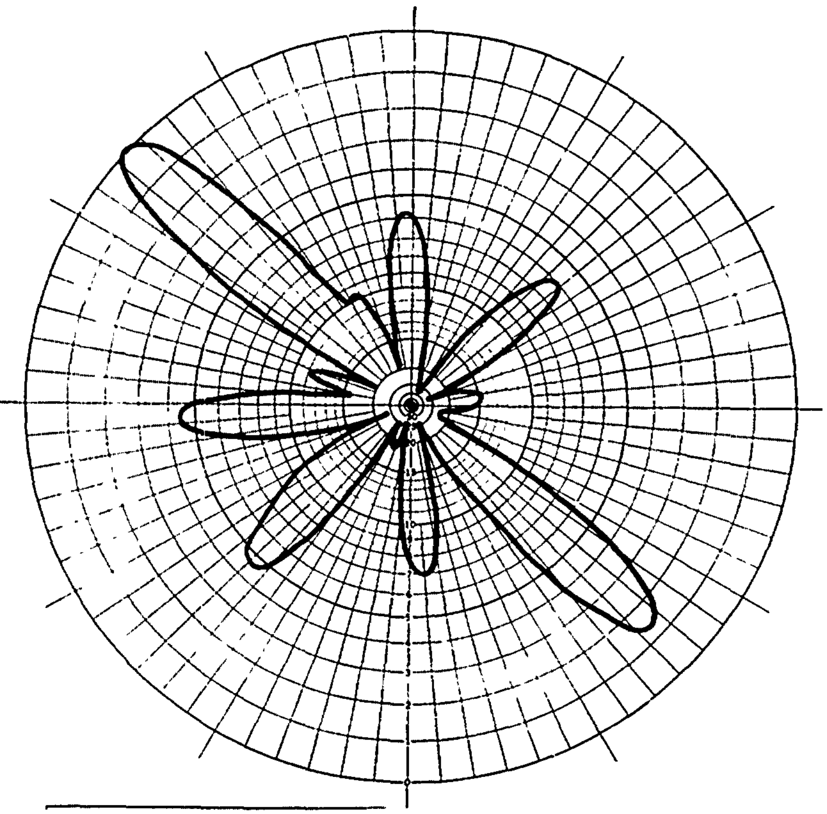


700 MHz, 10° Elevation,
0 = -2 db_i

Figure 29. Polar Patterns for the SATCOM Antenna

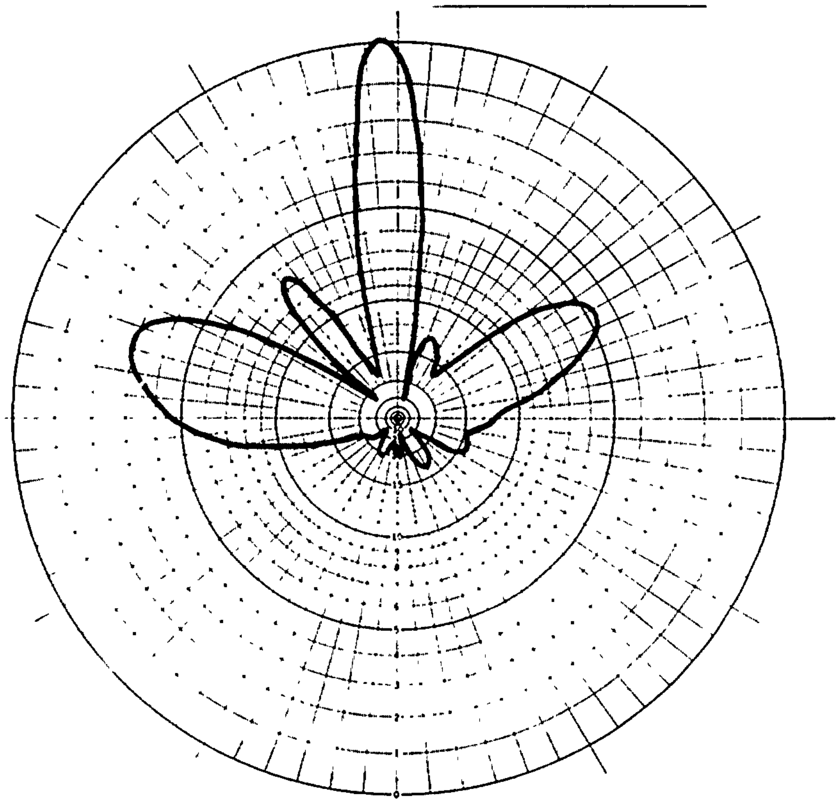


700 MHz, 50° Elevation,
0 = -6 db_i

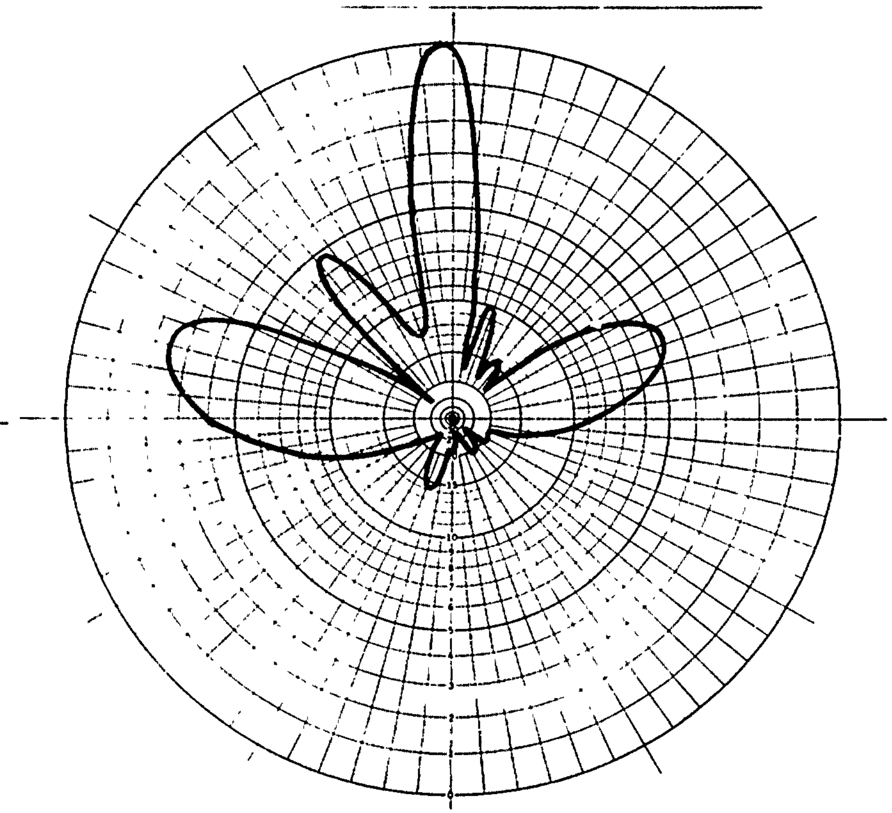


700 MHz, 90° Elevation,
0 = -7 db_i

Figure 30. Polar Patterns for the SATCOM Antenna

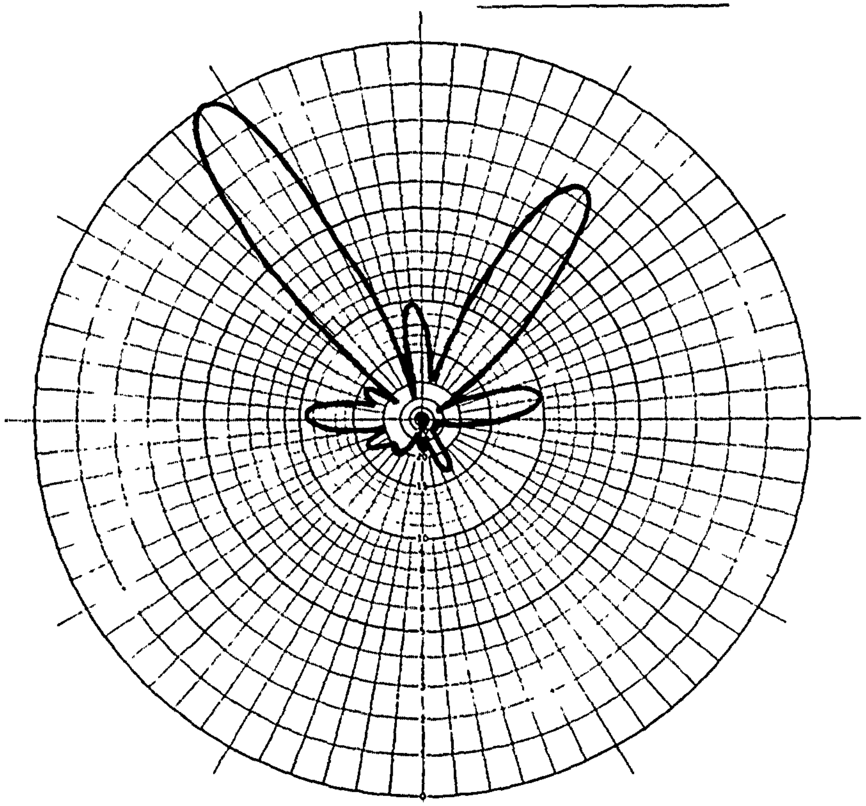


800 MHz, 0^{o} Elevation
$0 = -2.8\ db_i$

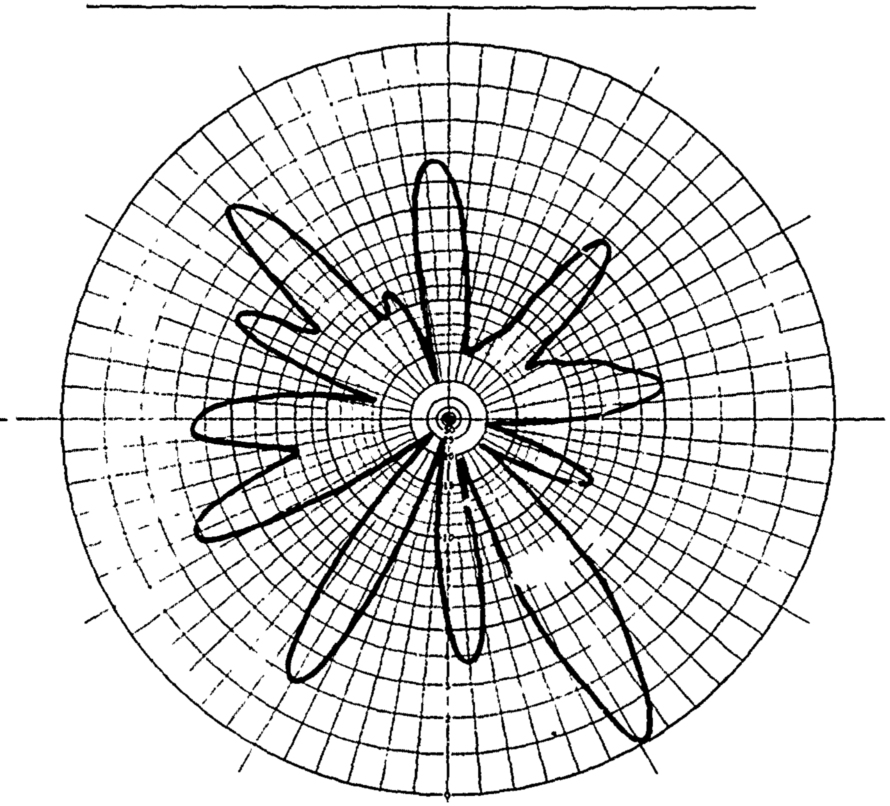


800 MHz, 10^{o} Elevation
$0 = -0.8\ db_i$

Figure 31. Polar Patterns for the SATCOM Antenna

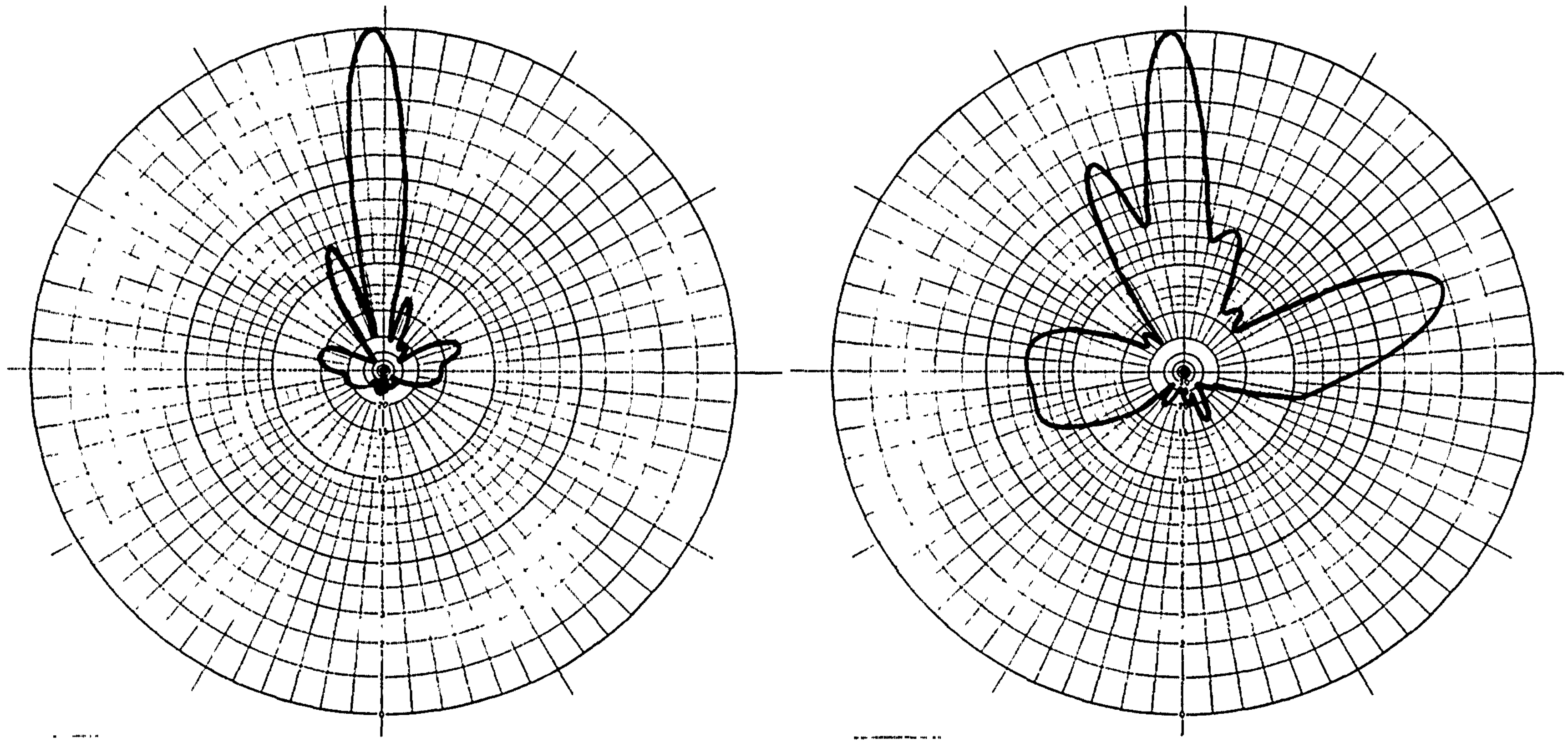


800 MHz, 50° Elevation
0 = +6.8 db_i



800 MHz, 90° Elevation,
0 = -3.8 db_i

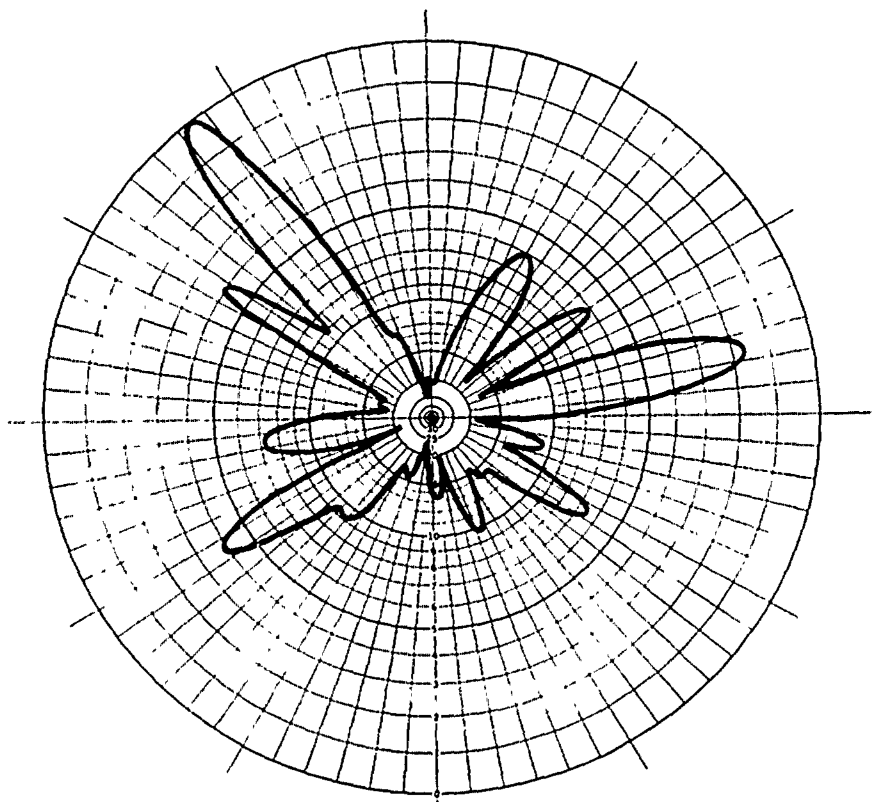
Figure 32. Polar Patterns for the SATCOM Antenna



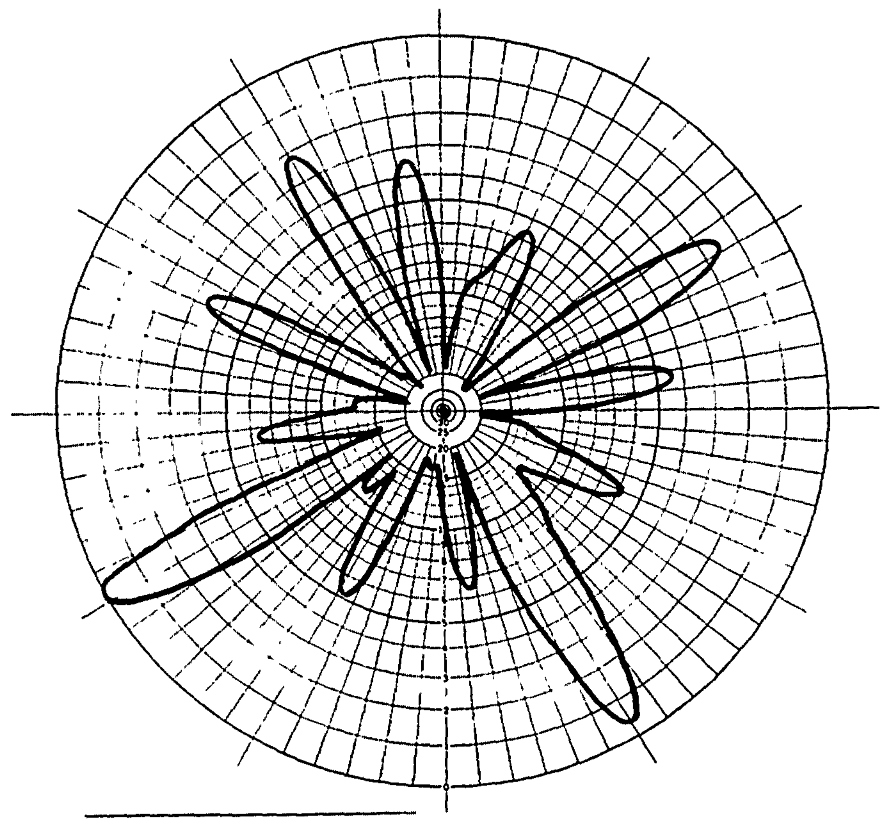
900 MHz, 0° Elevation,
0 = +6.5 db_i

900 MHz, 10° Elevation,
0 = +2.5 db_i

Figure 33. Polar Patterns for the SATCOM Antenna



900 MHz, 50° Elevation
0 = -6.5 db_i



900 MHz, 90° Elevation,
0 = -1.5 db_i

Figure 34. Polar Patterns for the SATCOM Antenna

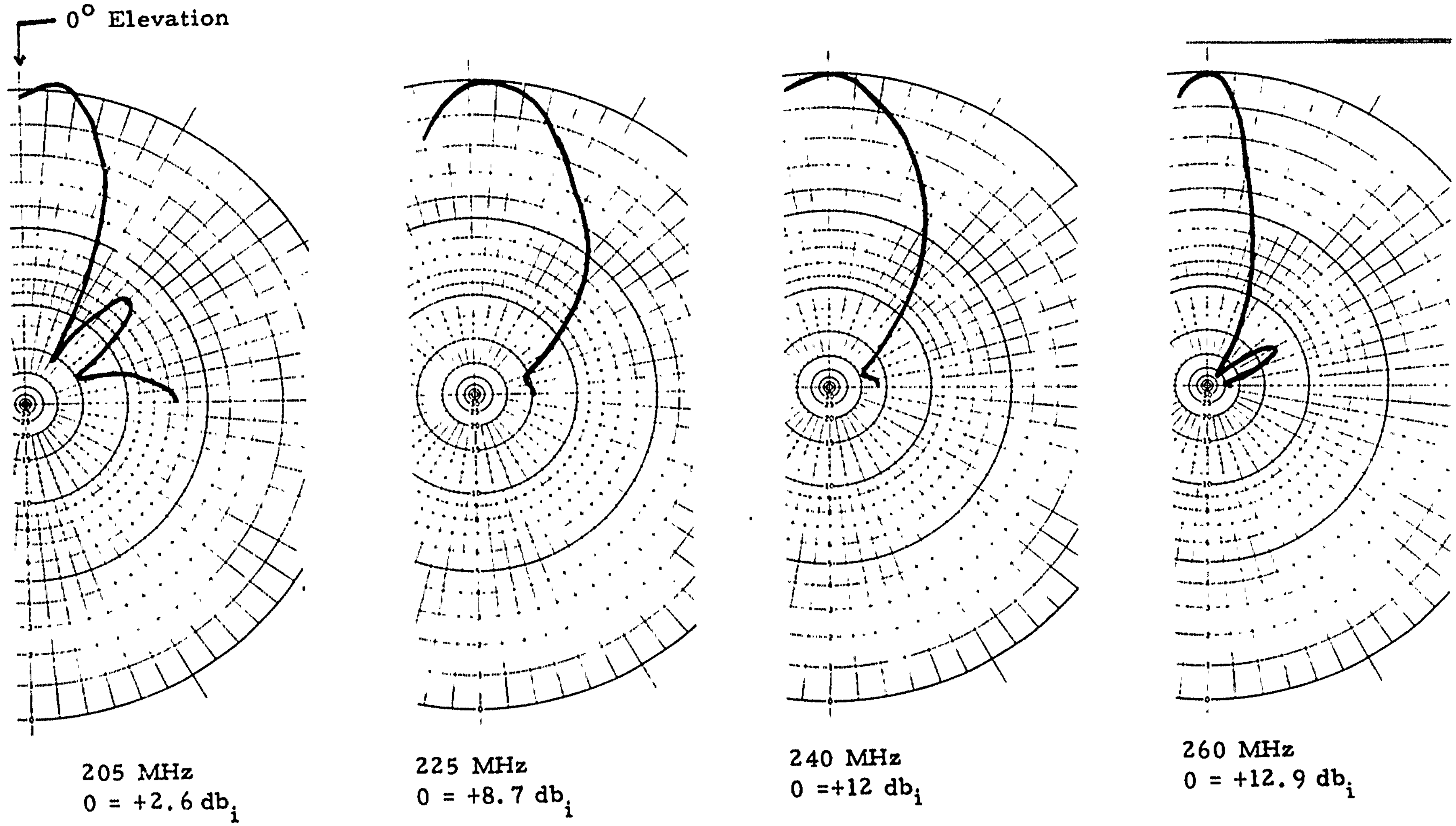


Figure 35. Elevation Patterns for the SATCOM Antenna

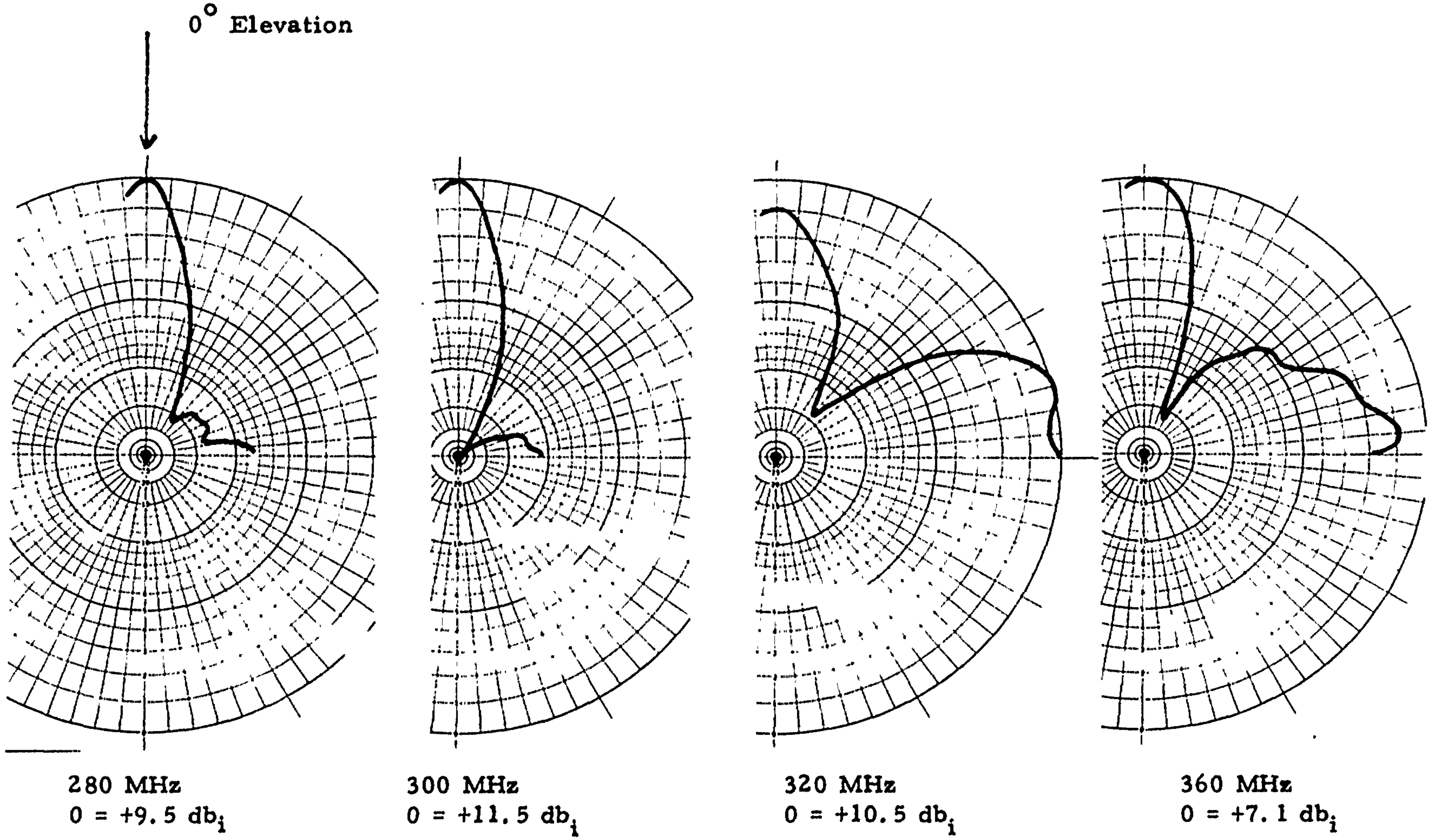


Figure 36. Elevation Patterns for the SATCOM Antenna

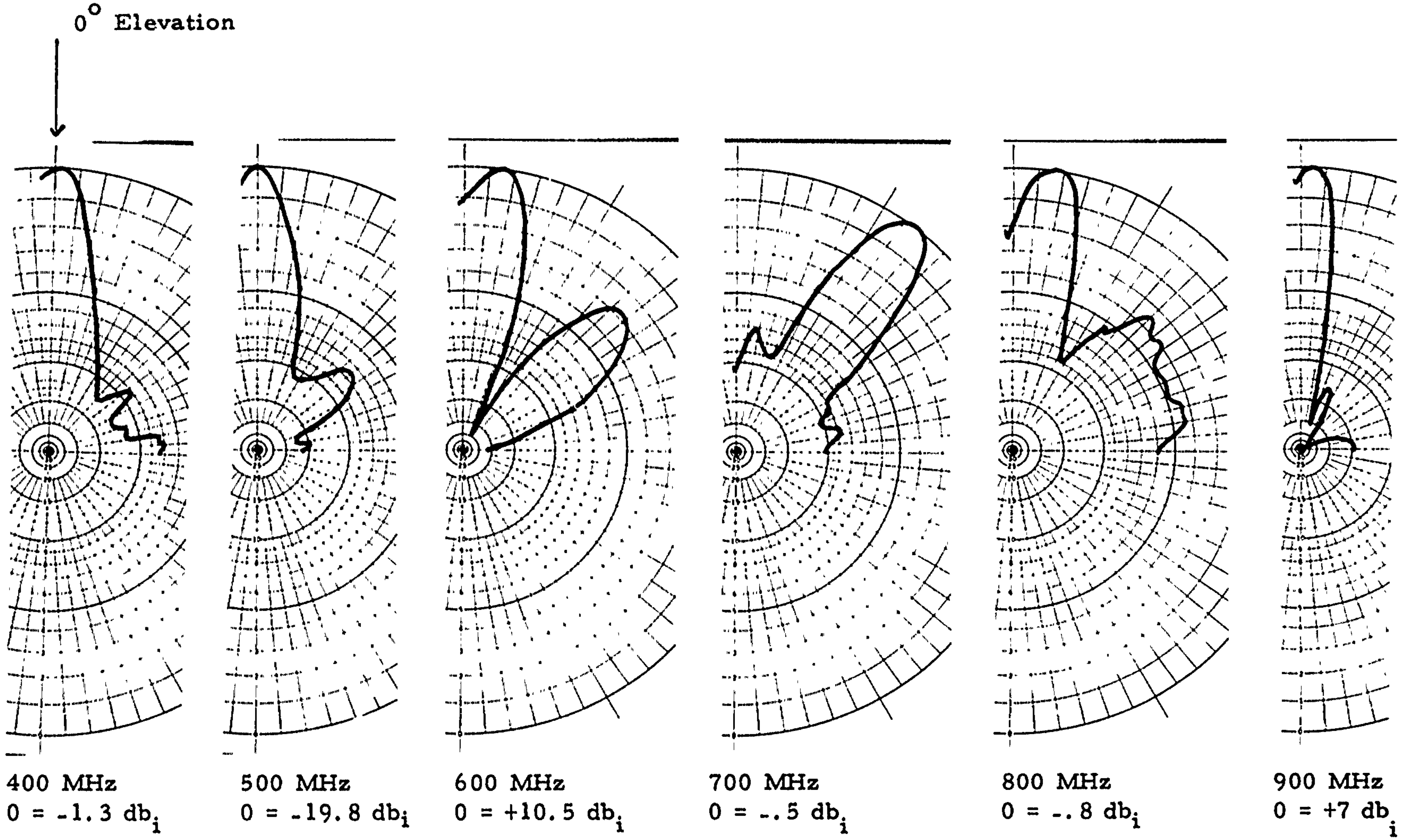


Figure 37. Elevation Patterns for the SATCOM Antenna

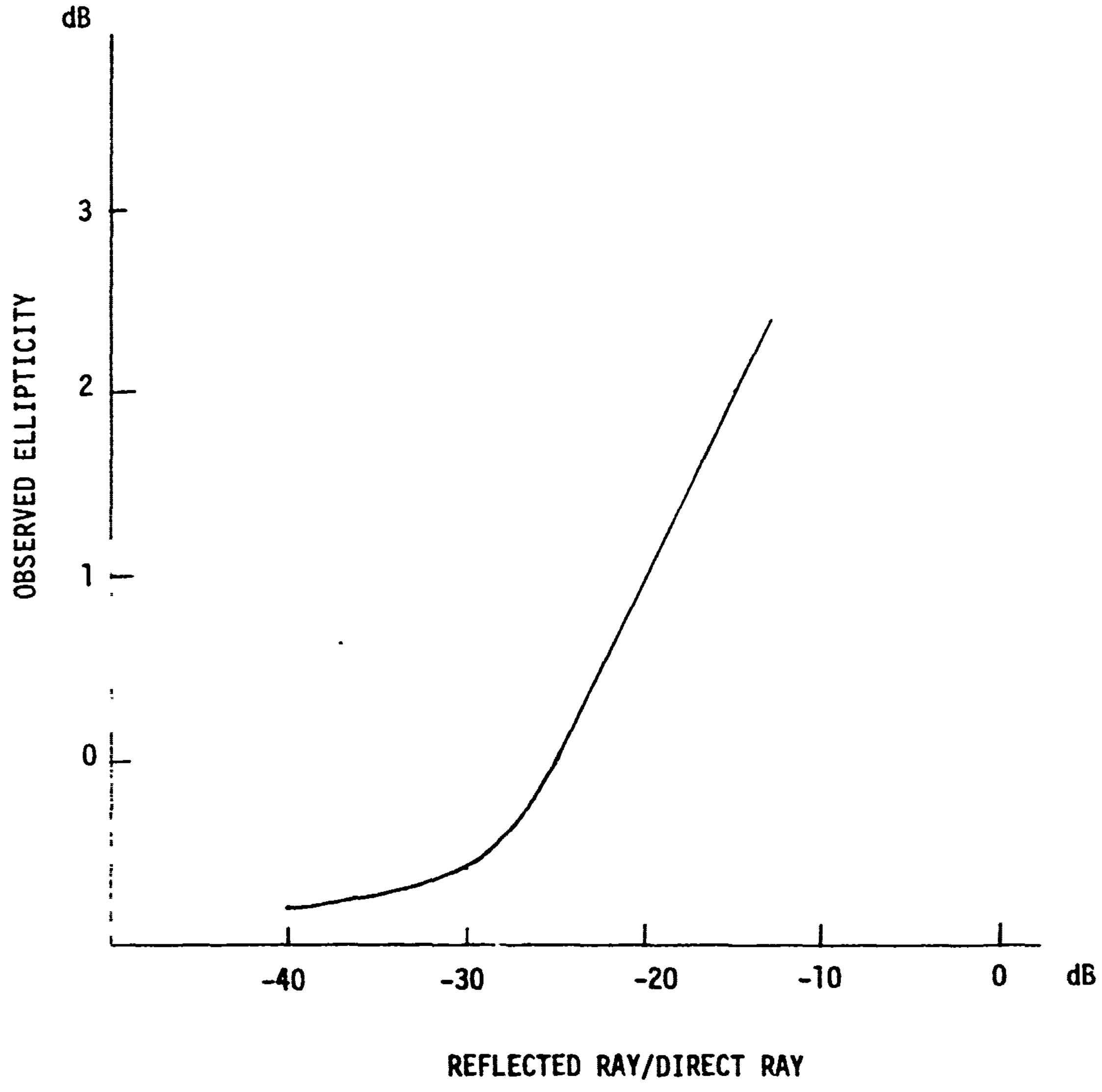


FIGURE 39. INFLUENCE OF THE REFLECTED WAVE ON THE MEASUREMENT OF A CIRCULARLY POLARIZED WAVE.

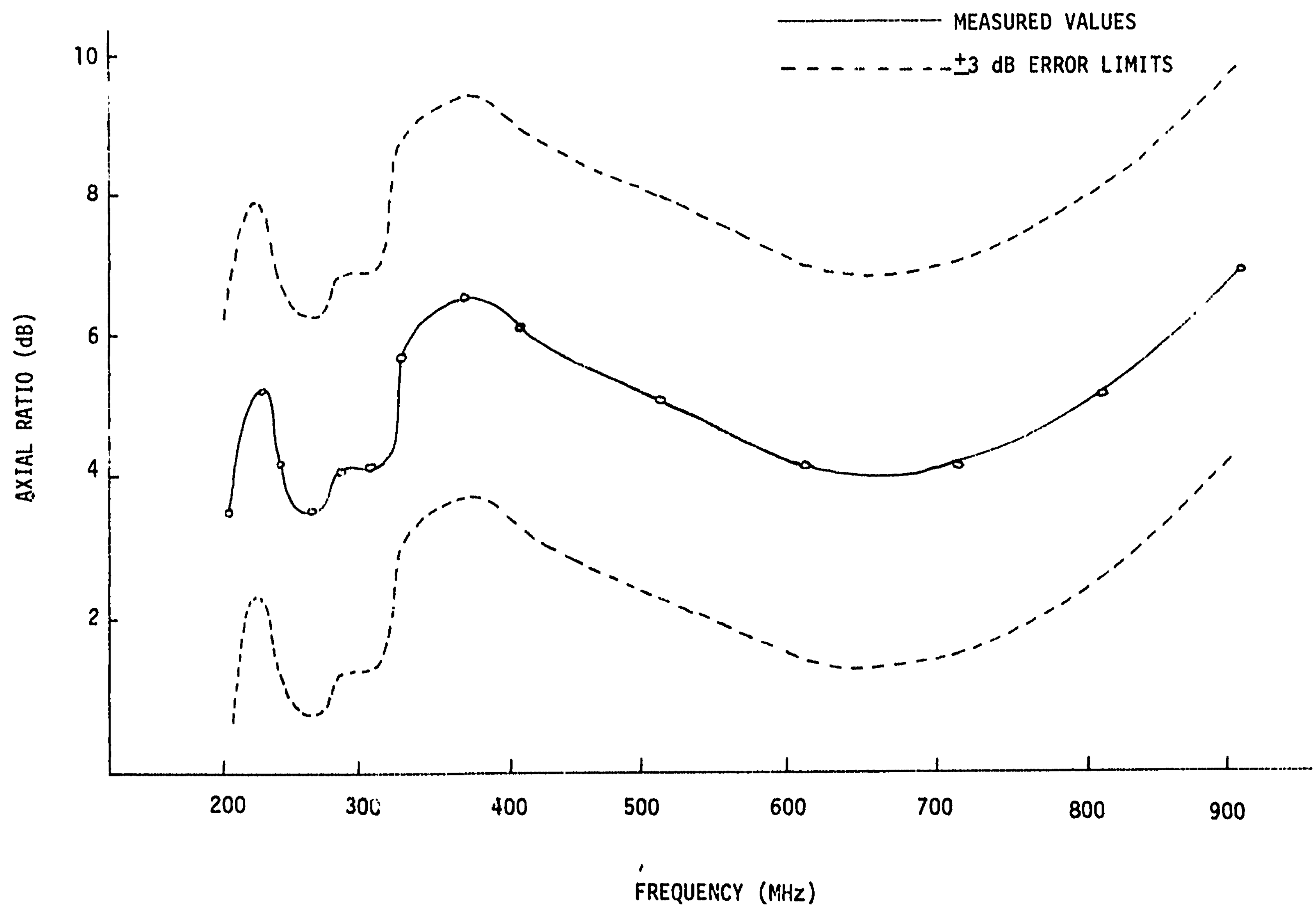


FIGURE 40. AXIAL RATIO VS. FREQUENCY FOR THE SATCOM ANTENNA

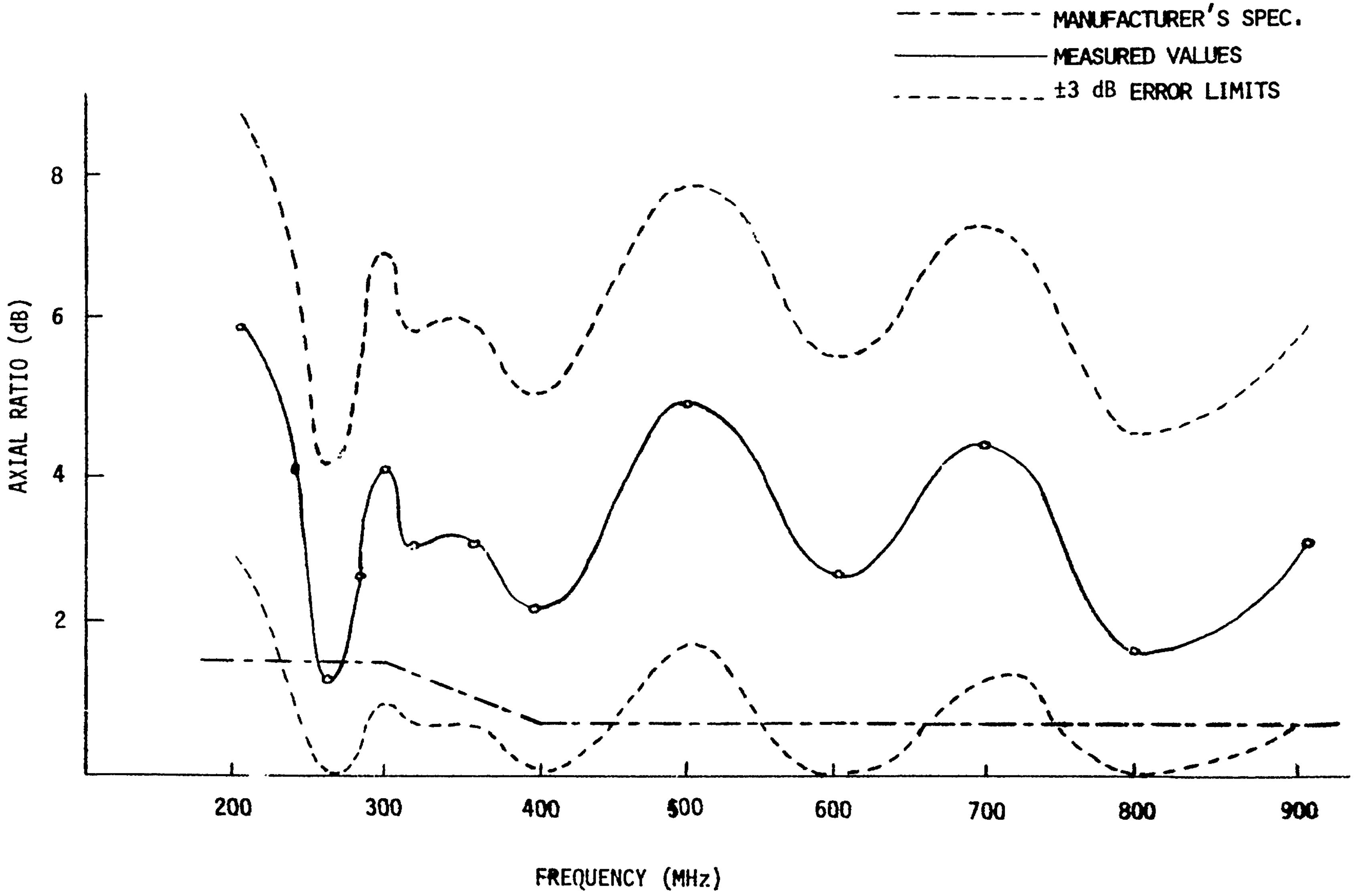


FIGURE 41. AXIAL RATIO VS. FREQUENCY FOR CONICAL LOG SPIRAL ANTENNA

E. VOLTAGE STANDING WAVE RATIO (VSWR) VS. FREQUENCY

The VSWR can be represented as

$$S = \frac{1 + K}{1 - K}$$

where K is the voltage reflection coefficient. An HP 8410A network analyzer was used to measure K. Cable losses were accounted for, with the SATCOM antenna producing VSWR as in Table 4. The conical log spiral data as measured and presented by the manufacturer is shown in Table 5.

III. CONCLUSIONS

A. PERFORMANCE BELOW NOMINAL BAND

The results of Part II clearly indicate that the AS-3018/WSC1-(v) SATCOM antenna is band limited to 240-320 MHz. Below 240 MHz, the gain is nearly isotropic at 200 MHz and increases to 11 dB at 240 MHz. The pattern shape remains good at 0° elevation with beamwidth > 40° and SLL < -7 dB. At higher elevation angles, side lobes increase and gain decreases as the main beam degenerates and "breaks-up."

B. PERFORMANCE IN NOMINAL BAND

The antenna performs as claimed by the manufacturer and in some instances is better. Pattern degradation still occurs at high elevation angles, but this is not to be taken as a deficiency in the antenna. Its intended elevation angle is 0° and no performance is specified at other angles.

C. PERFORMANCE ABOVE NOMINAL BAND

From 320 MHz up, the gain gradually decreases,

FREQUENCY	0° ELEVATION			90° ELEVATION	
(MHz)	K (dB)	VSWR	MANUFACTURER'S VSWR SPECIFICATION	K (dB)	VSWR
200	13	1.6		16	1.4
220	19	1.3		.9	1.3
240	17	1.3	1.5	17	1.3
260	35	1.0	1.5	30	1.0
280	19	1.3	1.5	20	1.2
300	21	1.2	1.2	18	1.3
320	20	1.2		16	1.4
340	20	1.2		14	1.5
360	17	1.3		12	1.7
380	12	1.7		7	2.6
400	8	2.3		2	8.7
500	8	2.3		3	5.8
600	2	8.7		3	5.8
700	3	5.8		3	5.8
800	12	1.7		16	1.4
900	12	1.7		11	1.8

TABLE 4. VSWR vs. FREQUENCY FOR THE SATCOM ANTENNA

FREQUENCY	K	VSWR	MANUFACTURER'S VSWR SPECIFICATIONS
(MHz)	(dB)		
200	10	1.9	3.2
300	10	1.9	3
400	13	1.6	2.8
500	8	2.3	2.6
600	10	1.9	2.3
700	11	1.8	2.7
800	9	2.1	2.0
900	8	2.3	1.5

TABLE 5. VSWR VS. FREQUENCY FOR THE CONICAL LOG SPIRAL ANTENNA

the main beamwidth narrows and side lobes increase until above 400 MHz the beamwidth is reduced by approximately one third of nominal values and side lobe levels fluctuate greatly. At several frequencies, side lobes are the prevalent beams. The VSWR also increases to an average of > 3:1 from an average of 1.5:1 in the nominal band. If the radiating elements are assumed to be some type of broadband crossed dipoles, operation outside of the design band could readily result in such performance as is observed from the AS-3018.

D. SUMMARY

The AS-3018 has a useful bandwidth of 200 to 320 MHz with the reservations of low gain and high side lobes below 240 MHz. Use above the 320 MHz limit might be made but the results achieved will depend greatly on the environment present and the acceptable level of performance. A shipboard environment will in almost all instances yield poorer results than were attained here simply because of the more cluttered environment of a ship. For example, the axial ratio data may not appear useful at first glance due to the ±3 dB possible error. On a "cleaner" range, results closer to the theoretical prediction might be obtained. However, considering the site of these measurements and noting that a shipboard site would certainly be even less ideal, the data becomes more realistic and may be presented as a reasonable indication of the actual operational characteristics of the antenna.

The conical log spiral has a wider bandwidth but lower gain. From 200 to 400 MHz the spiral was worse than an isotrope. Nevertheless, it did meet all of the manufacturer's specifications including gain. Its only limitation for shipboard RFI measurement usage is physical mounting ruggedness. This was easily remedied by fabricating a robust mounting structure.

REFERENCES

1. Hollis, S. J., Lyon, T. J. and Clayron, L., Jr. Microwave Antenna Measurements, Ch. 6, 7, 8, 10, 14. Scientific Atlanta, Inc., 1970.
2. Jasik, H. Antenna Engineering Handbook, Ch. 17, p. 17-9 and Ch. 34, McGraw-Hill, 1961.

INITIAL DISTRIBUTION LIST

		No. of Copies
1.	Defense Documentation Center Cameron Station Alexandria, VA 22314	12
2.	Library, Code 0212 Naval Postgraduate School Monterey, CA 93940	2
3.	Dean of Research, Code 023 Naval Postgraduate School Monterey, CA 93940	1
4.	Associate Professor John E. Ohlson, Code 530L Naval Postgraduate School Monterey, CA 93940	10
5.	Associate Professor Richard W. Adler, Code 52Ab Naval Postgraduate School Monterey, CA 93940	10
6.	LCDR C. J. Waylan, Code PME 106-111 Naval Electronics Systems Command Washington, DC 20360	40
7.	Professor Donald E. Kirk, Code 52 Naval Postgraduate School Monterey, CA 93940	1